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HEADQUARTERS STRATEGIC AIR COMMAND

Directorate of Aircraft Maintenance

Aircraft Engineering Division

Engineering Report No. P-425

Aircraft Chocks

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FOR THE COMMANDER

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1. **PURPOSE:** This report presents the results of a project to determine the optimum chock for a given aircraft.

2. **FOREWORD:**

a. In May 1982, HQ SAC/LGME was requested to provide engineering assistance in analyzing limitations of the current 5 inch chock and do a feasibility study on developing an engine run chock.

b. The chocks used for the -135 and B-52 aircraft are of a standardized design, 5 inches high, see attachment 1. The chocks are used to restrain the aircraft under no engine power and idle engine power conditions. Depending on the number of chocks used, the current chock can satisfy these requirements. What was not known was under what configuration and engine power settings will the chock restrain the aircraft?

c. The restraint capability of the chocks must be known in order to develop guidelines for engine run operations. Aircraft accidents have been caused by brake failure during maintenance engine runs; causing the aircraft to jump the chocks. Preliminary calculations were made and guidelines for engine run operations were sent to all affected units (See attachment 2).

d. To prevent further similar accidents, an in-depth laboratory and numerical analysis was conducted. From this analysis, a verification of the current engine run procedures was made, the restraint capability of the current 5 inch chock was determined, the standard chock was modified and tested, and a prototype engine run chock was designed and tested.

3. **CONCLUSIONS:**

a. Because of the difficulty in quantifying tire deflection, tire compression, chock design, and their interrelated reactions, an empirical formula for chock restraint capability is extremely difficult to develop.

b. The most accurate means of determining the restraint capability of a given chock against a given tire is to do a laboratory test.

c. The engine run procedures of SAC Supplement 1 to AFR 60-11 (attachment 2) are adequate when the aircraft has all eight tires chocked. The B-52H has the lowest margin of safety.

d. The restraint capability of the current 5 inch chock can be significantly improved by increasing its height by 1.5 inches.

e. The current 5 inch chock can be used for the KC-135R, but a 6.5 inch chock will significantly improve the margin of safety for engine run operations.

f. Without having a specified ramp location and a means of securing the chock to the ramp, an engine run chock does not improve the restraint capability enough to warrant its cost and handling problems.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A tire chock is the most common means to restrain an aircraft while it is parked. However, during certain ground operations, the chock is unable to restrain the aircraft. An analysis was done on the restraint capabilities of the current chocks used for the B-52 and -135 aircraft. From this analysis, safety factors and operating limitations were established. In addition, criteria was developed for chock improvements as they are related to the various engines on the B-52G, B-52H, KC-135A, KC-135E and KC-135R.

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4. **RECOMMENDATIONS:**

a. A 6 - 6.5 inch chock be used on the KC-135R and B-52H aircraft.

b. Laboratory or field tests be conducted on various tire and chock combinations to confirm chock restraint capability when brake failure occurs. The test results could also be used to accurately establish engine run operating procedures.

5. **DISCUSSION:**

a. Chocks are generally used with little regard to tire size, surface conditions, and actual restaint requirements. As a result, some accidents have occurred because the chock failed to restrain the vehicle under certain conditions. Even though the accident may have been caused by operator neglect, the unacceptable end result was aircraft damage.

b. The main thrust of this project was to determine the restraint limitation of the current 5 inch chock for the KC-135 and B-52. In addition, information gained in this project would be used to develop a conceptual chock design for engine run maintenance operations. The ultimate goal was to develop a chock that would restrain the aircraft, without brakes, during engine run operations.

c. The first phase of the project was to determine the operating limitations of the current chock. The ideal approach is to develop a mathematical model that would simulate the forces generated between a tire and a chock. There were two mathematical models that were looked at to simulate tire-chock force relationships; the ramp analysis and the step analysis.

d. The ramp analysis assumes that the action of a tire rolling over a chock is similiar to a wheel rolling up an incline.

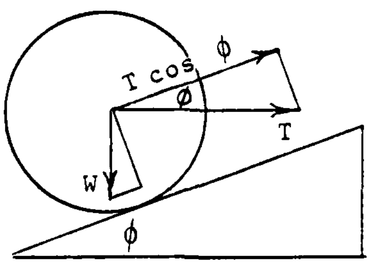
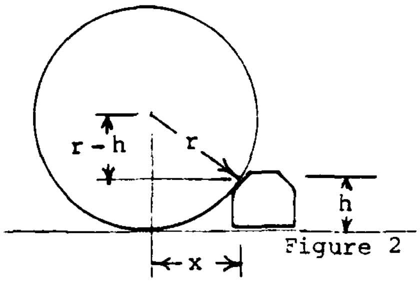


Fig 1

Figure 1 shows the force relationships between the wheel and the incline. The mathematical model of the ramp analysis is a relationship between the horizontal force (T), the vertical force (W), and the angle of the incline (Ø). Relating this to a tire rolling over a chock, T is the amount of thrust required to roll over a chock, given the weight on the tire (W) and the height of the chock. Using this analysis, a method is required in determining the angle of incline (Ø) as a function of tire diameter and chock height.

e. To determine $\emptyset$, a geometrical approach was taken, see fig 2.



r = tire radius
h = chock height
$\emptyset$ = ramp angle

Figure 2

Given the tire radius and the chock height, the value of x can be determined by the following relationship:

$$X = [h\ (2r-h)]^{1/2}$$

The value of $\emptyset$ can be determined by taking the inverse tangent of the chock height divided by the calculated value of x,

$$\emptyset = \mathrm{TAN}^{-1} \frac{h}{x}$$

This approach does not take into account the tire deflection against the support surface and the chock.

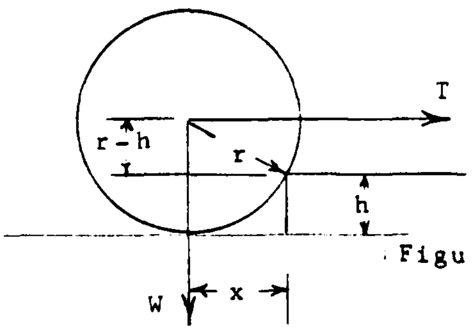
f. For a given tire diameter and chock design, the angle $\emptyset$ can be determined. Then by knowing the aircraft weight excerted on the tire, the amount of thrust (T) or horizontal force required to roll over the chock can be determined by using the following relationship:

$$T \cos \emptyset = w \sin \emptyset$$

Solving for T

$$T = W \frac{\sin \emptyset}{\cos \emptyset} = W \tan \emptyset$$

g. If we assume that the tire rolling over a chock acts like a wheel rolling up a step, the mathemetical model would have to be altered. Figure 3 depicts the force relationships for the step analysis.



T = Thrust
W = Weight
r = tire radius
h = height of chock

Figure 3

As in the ramp analysis, the step analysis is a relationship between horizontal force (T), vertical force (W), tire size, and height of the chock. The amount of thrust required to roll over a chock (using the step analysis) is:

$$T\,(r-h) = W(X)$$

$$T = \frac{W\,(X)}{r-h}$$

The only factor not readily available is the distance "X". However, "X" is a simple geometrical relationship between tire radius (r) and chock height (h).

$$X^2 + (r-h)^2 = r^2$$

Solving for X

$$X^2 + r^2 - 2rh + h^2 = r^2$$
$$X^2 = 2rh - h^2$$
$$X = [h(2r-h)]^{1/2}$$

Substituting x into the thrust formula.

$$T = \frac{W\,[h\,(2r-h)]^{1/2}}{r-h}$$

If the size of the tire, the chock height, and the weight on the tire are known, the amount of thrust, required to roll over a chock, can be determined.

h. The problem now is which mathematical model most closely replicates an actual tire rolling over a chock. Both the ramp and step analysis discount several variables inherent with a tire rolling over a chock, such as tire deflection versus aircraft weight, coefficients of friction between surfaces, tire pressure, and tire composition characteristics. Therefore, the ramp and step analysis methods had to verified with actual data.

i. The actual data was obtained by setting up a laboratory simulation at AFWAL/FIEMA, Wright Patterson AFB, OH. The purpose of the laboratory test was to determine the drag force/axial force, as a function of tire loading, exerted against a B-52 and a KC-135 tire before it rolls over a chock, see attachment 3 for details.

j. By taking the laboratory data and comparing it against each mathematical model, a margin of error can be established for each model. The margin of error is calculated by substracting the calculated data from the lab data and dividing the result by the lab data.

$$E = \frac{F_L - F_C}{F_L}$$

F_L = lab force
F_C = calculated force
E = percent of error

The lowest margin of error would establish which model is the best and what degree of accuracy can be expected. Tables 1 and 2 are a tabulated comparison between the mathematical models and the laboratory test data for a KC-135 main gear tire.

x = 14.8 inch
h = 5 inch chock height
T_p = 140 tire pressure

LOAD (W)	Calculated force (F_C)	Lab Force (F_L)	% Error (E)
10,000	3371	5500	39
15,000	5056	7100	29
20,000	6742	8300	19
25,000	8427	9000	6
30,000	10113	9300	9
35,000	11798	9800	20

Table 1

Comparison of calculated and laboratory Restraint Force using the Ramp Analysis

LOAD (W)	F_C	F_L	% Error (E)
10,000	7590	5500	38
15,000	11385	7100	60
20,000	15179	8300	83
25,000	18974	9000	111
30,000	22769	9300	145
35,000	26564	9800	171

Table 2

Comparison of calculated and laboratory Restraint Force using the Step Analysis

Tables 1 and 2 are based on a standard 49 inch diameter KC-135 tire, inflated to 140 psi, and restrained by a 5 inch chock. The results of these comparisons indicates that the ramp analysis more closely replicates the actual measured results than does the step analysis. This also depicts that the accuracy of the ramp analysis is only accurate in the medium load range.

i. The same analysis techniques can be used to compare chock restraint forces using a 56 diameter B-52 tire. Tables 3 and 4 compare the calculated and laboratory forces that a B-52 tire, inflated to 300 psi, exerts against a 5 inch chock.

LOAD (W)	Calculated force (F_C)	Lab Force (F_L)	% Error (E)
20,000	6262	11000	43
30,000	9393	14000	33
40,000	12524	16400	24
50,000	16400	18300	10
60,000	18787	19800	5
75,000	21918	21200	3

Table 3

Comparison of Calculated and Laboratory Restraint Force using the Ramp Analysis

LOAD (W)	F_C	F_L	% Error (E)
20,000	13878	11000	26
30,000	14445	14000	3
40,000	27756	16400	69
50,000	34696	18300	90
60,000	41635	19800	110
70,000	48574	21200	229

Table 4

A-1

Comparison of Calculated and Laboratory Restraint Force using the Step Analysis

j. The results of the B-52 tire comparison show that the ramp analysis more closely replicates the measured test results than does the step analysis, especially in the high load ranges where tire deflection is greatest. However, the step analysis showed better accuracy in the lower load ranges where tire deflection is minimum.

k. The above two comparisons indicate that the actual mathematical model is a combination of both the ramp and step analysis techniques. In addition, the inclusion of tire compression against the support surface and the tire deflection against the chock into the mathematical model are required to achieve reasonable accuracy. Since tire compression and tire deflection are functions of tire pressure, tire loading, chock design, and tire design, an emperical formula, that accurately depicts the relationship between all these variables, would be extremely difficult to formulate. In those cases where the ramp and step analysis techniques are reasonably accurate, the range of useage is extremely small. Therefore, this limits their usefulness and may lead to erroneous chock restraint capabilities if used outside this range.

l. As a result of the high error percentage associated with the above mathematical models, the only accurate way to reflect the true chock restraint capability is to do a laboratory test for a given tire diameter.

The lab test set up at WPAFB reflected tire pressure, the range of operational loads, and associated chock design. From these results, operational restrictions, fuel loads, and engine run maintenance tech data can be formulated. A comfortable safety margin can also be built in without guessing at the errors associated with a particular mathematical representation of the chock restraint capabilities. Attachments 4 and 5 represents the tabulated results and graphical representation of the laboratory test results for B-52 and KC-135 tires restrained by a standard 5 inch chock.

m. Assuming that it takes an equal amount of thrust to overcome a specified restraint force, the test data in attachments 4 and 5 can be used to reflect the amount of engine thrust restraint capability of a standard 5 inch chock. To make the data more useful, data representation should reflect aircraft gross weight, type of aircraft, and type of engine. This report will concentrate on B-52 aircraft equipped with J57-P-43WB (B-52G) and TF33-P-3 (B-52H) engines and KC-135 aircraft equipped with J57-P-59W (KC-135A) and TF33-PW-102 (KC-135E) engines. For the B-52, a 45/55 forward/aft gear weight distribution was used. For the KC-135, gross weight was calculated using 24% Mean Aerodynamic Cord (MAC) for the center of gravity.

n. To calculate the gross weight for a KC-135, the center of gravity station number and the tire loading is required. The main landing gear (MLG) weight is determined by multiplying the tire load by eight MLG tires.

wt/tire x 8 MLG tires = MLG wt

To translate the main landing gear weight to aircraft gross weight, the lever arm relationship between the center of gravity and the forward and aft gears is calculated. Using 24% MAC as the center of gravity, the distance from 0% MAC to 24% MAC is calculated by multiplying 24 by 2.4188 inches.

24 x 2.4188 = 58.0512 inches from 0% MAC

The station number of 0% MAC is 786.2 inches, therefore, the center of gravity station number is:

786.2 in. + 58.0512 in = 844.2512 inches

Using 887 for the MLG station number and 339 for the forward landing gear (FLG) station number, the distance between the gears is:

887 - 339 = 548 inches

To determine the lever arm relationship, the distance between the center of gravity and the FLG is required. The distance is:

844.2512 - 339 = 505.2512 inches

By dividing the CG - FLG distance by the FLG-MLG distance, the percentage of weight the MLG supports is determined.

$$\frac{505.2512}{548} = .922$$

The aircraft gross weight is calculated by dividing the MLG weight by the weight distribution percentage.

$$\frac{MLG}{.922} = \text{Aircraft gross weight}$$

Table 5 is a tabulation of -135 gross weight versus individual tire loading.

Tire Loading (lbs)	Gross Weight (lbs)
10,000	86,768
15,000	130,152
20,000	173,536
25,000	216,920
30,000	260,304
35,000	303,688

Table 5
-135 Gross Weight v.s. Tire Loading

o. For the B-52, a 45/55 forward/aft gear weight distribution was used. By knowing the tire loading for the forward gear tire, the tire loading on the aft gear tire is calculated by the following relationship, and vice versa,

$$\frac{\text{Forward Land Gear (FLG)}}{.45} = \frac{\text{AFT Loading Gear (ALF)}}{.55}$$

The aircraft gross weight is determined by adding the FLG tire load and ALG tire load and multiplying the results by four (FLG tire load + ALG tire load) x 4 = Gross Wt. Table 6 is a tabulation of B-52 gross weight versus ALG tire loads.

ALG Tire Load (lbs)	FLG Tire Load (lbs)	Gross Weight (lbs)
20,000	16364	145,456
30,000	24545	218,182
40,000	32727	290,909
50,000	40909	363,636
60,000	49091	436,364
70,000	57273	509,091

Table 6
B-52 Gross Wt v.s. Tire Loads

p. Before aircraft gross weight versus engine thrust can be graphed, the number of chocked tires must be known. For purposes of this report, four and eight chocked tire configurations will be considered. Using these configurations, the associated engine thrust cancellation or chock restriant capabilities was determined using the lab data specified in attachments 4 and 5. For -135 aircraft, the average max chock restraint force was multiplied by the number of chocked tires for each tire load, see Table 7.

Gross Weight (lbs) (Table 3)	AVG MAX CHOCK RESTRAINT FORCE (FR)	
	4 Chock Tires	8 Chocked Tires
86,768	21840	43680
130,152	28320	56640
173,536	32720	65440
216,920	35920	71840
260,304	37440	74880
303,688	40320	80640

Table 7

-135 Gross Weight v.s. Average Max Chock Restraint Force
Standard 5" Chock

q. For B-52 aircraft, the chock restraint force for the forwa[illegible] and aft landing gear is determined separately because of the 45/55 weight distribution. For the four chocked tire configuration, only the f[illegible]t landing gear tires are assumed to be chocked. The effective restra[illegible] force of four chocked tires is determined by multiplying the average chock restraint force (attachment 5), by four for each tire loading. For the eight chocked configuration, the restraint force exerted against the forward landing gear tire loads, specified in Table 6, are interpolated off the graph in attachment 5. Table 8 gives B-52 gross weight versus average max chock restraint force for the four and eight chocked tire configurations.

Gross wt (lbs) Table 4	AVG MAX CHOCK RESTRAINT FORCE (FR)	
	4 Chocked Tires	8 Chocked Tires
96,364	43200	81200
218,182	55800	104800
290,909	65468	123868
363,636	72600	138600
436,364	78932	150932
509,091	84000	161000

Table 8
B-52 Gross Wt v.s. AVG MAX Chock Restraint Force
Standard 5" Chock

r. By using the direct correlation of engine thrust to chock restraint force, the amount of engine thrust a standard 5 inch chock can restrain, for a given aircraft gross weight, can be plotted. These plots can be expanded to represent the number of engines that can be restrained, given the type and power setting of the engine. Engine power settings will be reflected in Engine Pressure Ratio (EPR). The EPR value is specified because EPR does not vary with temperature and pressure altitude and is applicable to both wet and dry operation.

s. Using the values in Table 7, the average maximum restraint capability of a standard 5 inch chock can be plotted relative to engine thrust and aircraft gross weight for -135 aircraft, see Figures 4 and 5. Figure 4 also depicts the number of J57-P-59W (KC-135A) engines that can be restrainted using max power (wet), max power (dry), and approximately 90% RPM (standard day) (EPR 2.48). Thrust-to-EPR conversions are taken from a Boeing Co. Curve, see attachment 6. Weights are extracted from T.O. 1C-135(K)A-1. Figure 5 shows the same relationship for a TF33-PW-102 engine (KC-135E).

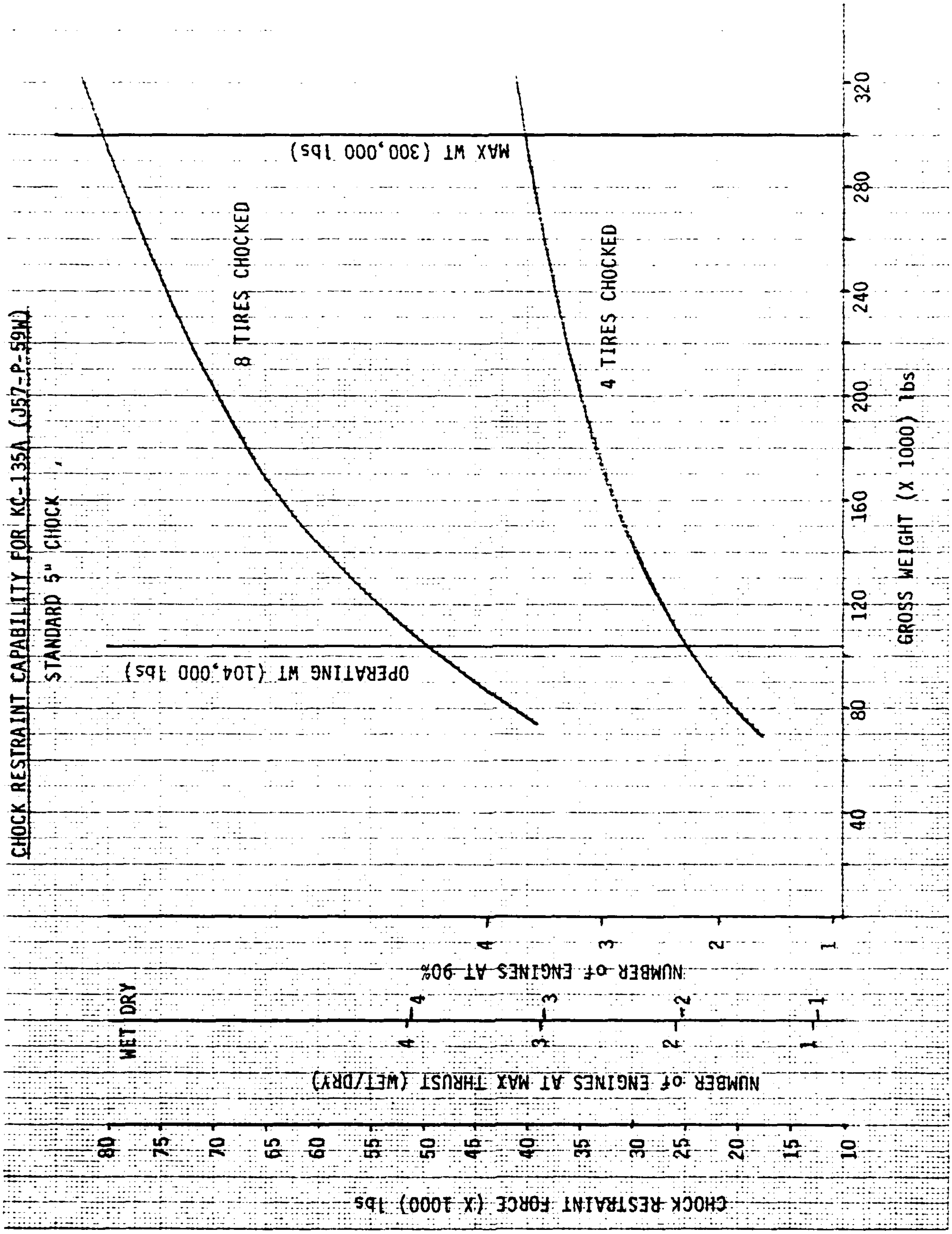
t. From figures 4 and 5, safe ground engine operating procedures can be determined for those cases where brake failure might occur. Figure 4 indicates that with all eight main landing gear tires chocked with a standard 5 inch chock on a KC-135A, the aircraft, with full thrust on four engines, would have to be extremely light weight before it would roll over the chocks. Referring to figure 5, under the same conditions, a KC-135E aircraft, with full thrust on four engines, would roll over the chock with only 50,000 lbs of fuel.

u. Using the values in Table 8, the average maximum restraint capability of a standard 5 inch chock can be plotted relative to engine thrust and aircraft gross weight for B-52 aircraft, see figures 6 and 7. The performance relationships for the J57-P-43WB (B-52G) and (TF88-P-3 (B-52H)) are depicted on figures 6 and 7 respectively. The weight and engine thrust specifications were extracted from T.O. 1B-52G-1 and T.O. 1B-52H-1. The EPR values were interpolated from a Boeing Co. plot, see attachment 7.

v. From figure 6, four chocked ties, no brakes, will restrain a B-52G aircraft, under any weight conditions, with full thrust on four engines. It also shows that the four chocked tires is a marginal restraint capability when all eight engines are operating. With eight tires chocked, a 80,000 lb fuel load and no brakes, the B-52G aircraft is reasonably restrained. For a B-52H aircraft, the same reasonable restraint would require a 200,000 lb fuel load, see figure 7.

w. The plots in figures 4 - 7 can also be used to certify the procedures for maintenance engine run operations, see atch 2. The main purpose of the AFR 60-11/SAC Sup 1 attachment 1 (Engine Operations Quick Reference Matrix) is to assure that the aircraft will not roll over a 5 inch standard chock during engine maintenance runs. By cross checking the number of engines, fuel load requirements, number of chocked tires, and type of aircraft, the lab results verify that the standard chock will restrain the aircraft if brake failure occurs. If the engine operator on a B-52H should run all 8 engines up to power and brake failure occurs, the aircraft will jump the chocks. If all eight MLG tires are chocked and only four engines are run, a comfortable margin of safety is built in to protect the aircraft under brake failure conditions.

x. With the modernization program for the -135, several -135 aircraft will be equipped with new engines (F108-CF-100) and redesignated as the KC-135R. The new KC-135R engine will provide approximately 22,000 pounds



CHOCK RESTRAINT CAPABILITY FOR KC-135A (J57-P-59W)
STANDARD 5" CHOCK
MAX WT (300,000 lbs)
8 TIRES CHOCKED
4 TIRES CHOCKED
OPERATING WT (104,000 lbs)
GROSS WEIGHT (X 1000) lbs
40
80
120
160
200
240
280
320
NUMBER of ENGINES AT 90%
4
3
2
1
WET
DRY
NUMBER of ENGINES AT MAX THRUST (WET/DRY)
CHOCK RESTRAINT FORCE (X 1000) lbs
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10

FIGURE 4

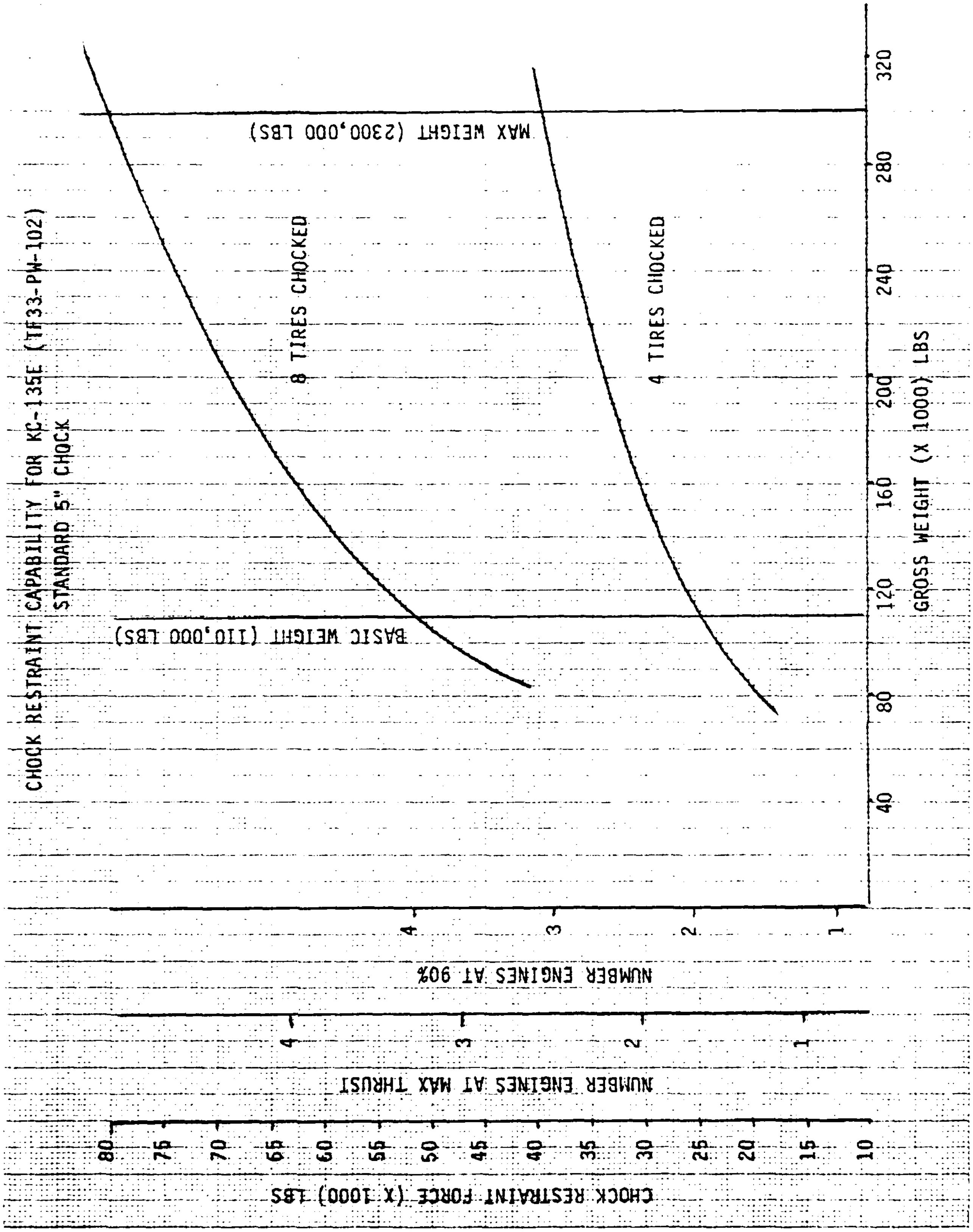

CHOCK RESTRAINT CAPABILITY FOR KC-135E (TF33-PW-102)
STANDARD 5" CHOCK
MAX WEIGHT (2300,000 LBS)
8 TIRES CHOCKED
4 TIRES CHOCKED
BASIC WEIGHT (110,000 LBS)
40 80 120 160 200 240 280 320
GROSS WEIGHT (X 1000) LBS
4 3 2 1
NUMBER ENGINES AT 90%
4 3 2 1
NUMBER ENGINES AT MAX THRUST
80 75 70 65 60 55 50 45 40 35 30 25 20 15 10
CHOCK RESTRAINT FORCE (X 1000) LBS

Figure 5

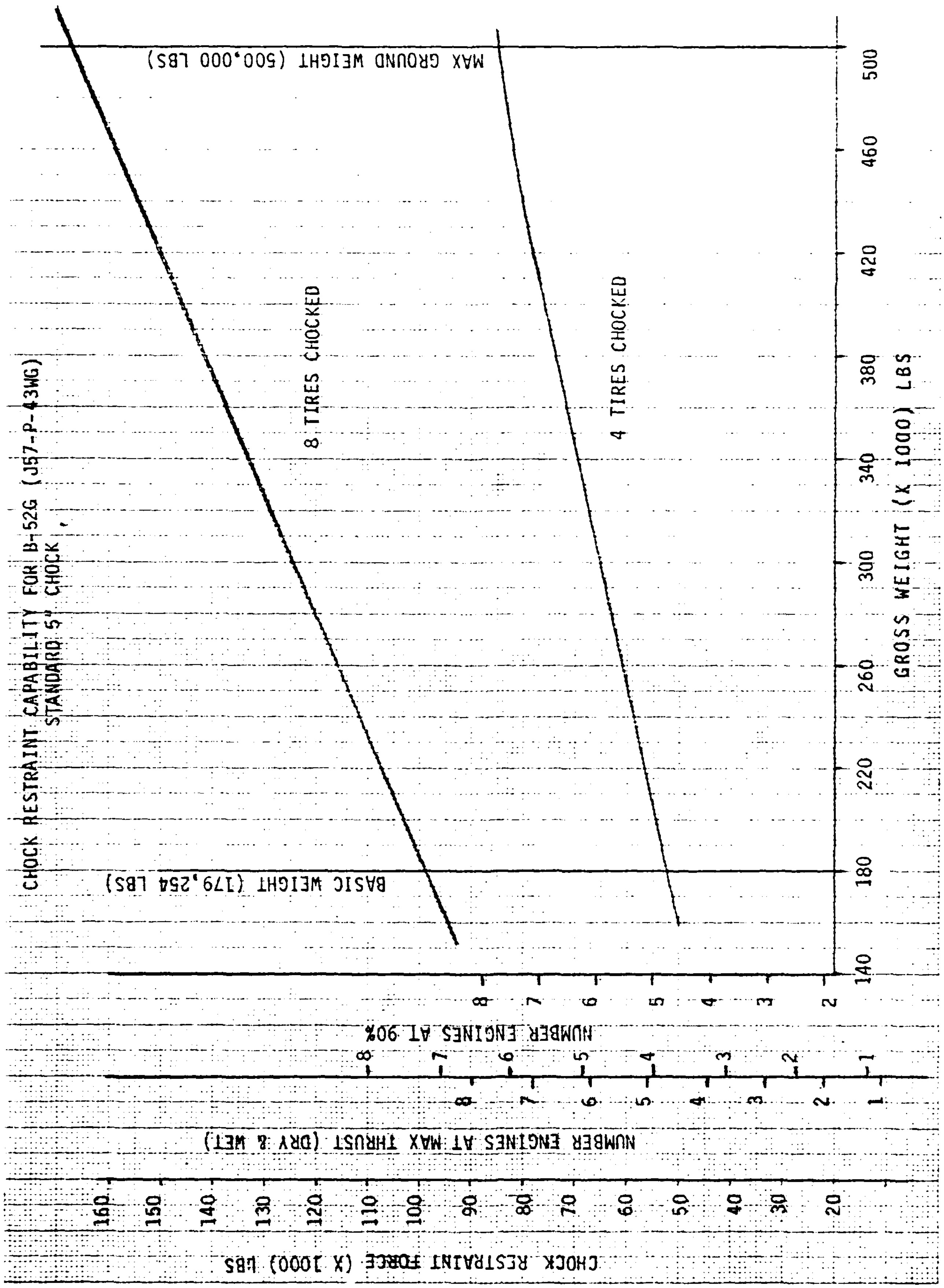

CHOCK RESTRAINT CAPABILITY FOR B-52G (J57-P-43WG)
STANDARD 5" CHOCK
MAX GROUND WEIGHT (500,000 LBS)
BASIC WEIGHT (179,254 LBS)
8 TIRES CHOCKED
4 TIRES CHOCKED
GROSS WEIGHT (X 1000) LBS
140
180
220
260
300
340
380
420
460
500
NUMBER ENGINES AT 90%
NUMBER ENGINES AT MAX THRUST (DRY & WET)
CHOCK RESTRAINT FORCE (X 1000) LBS
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20

Figure 6

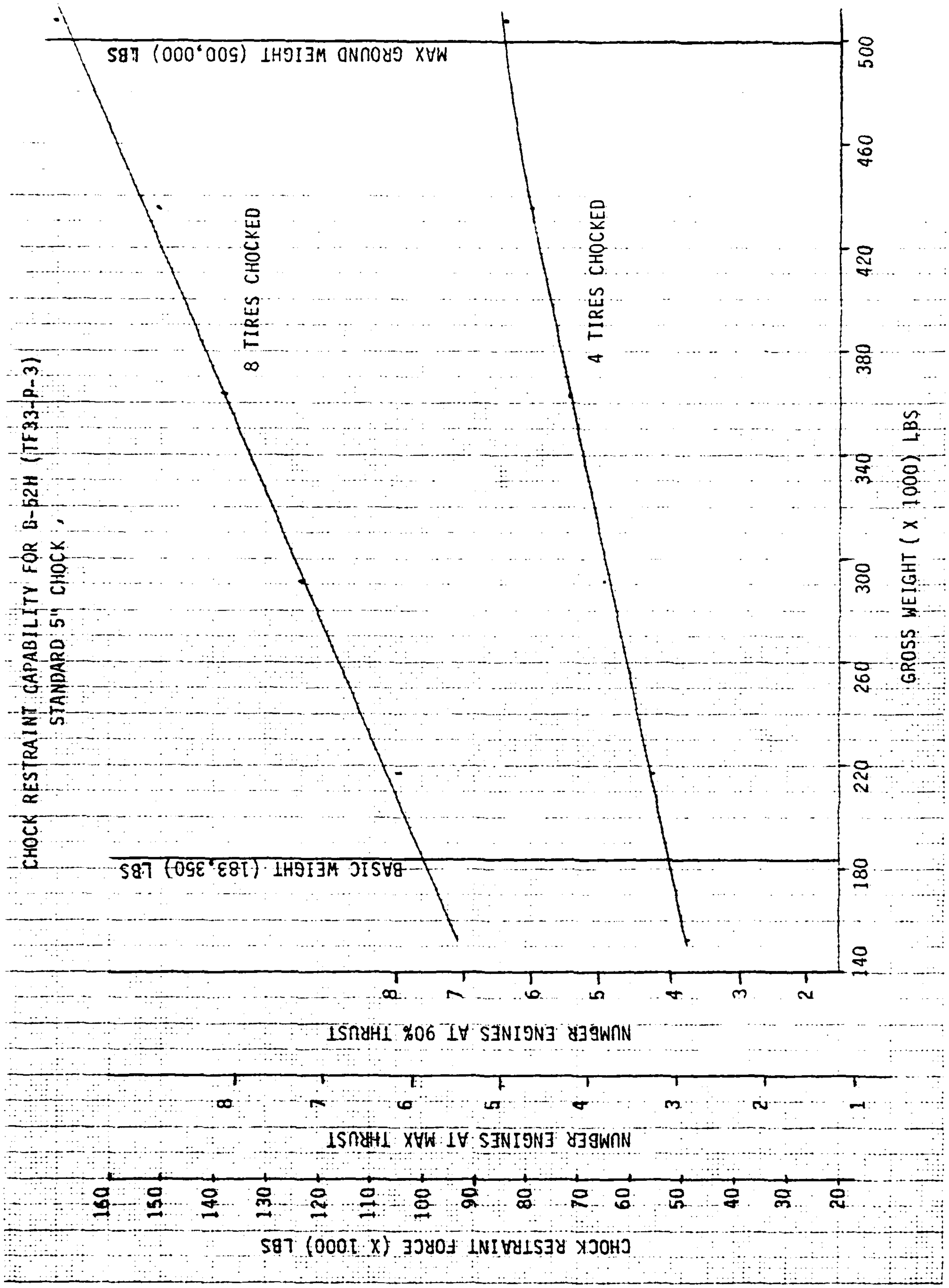
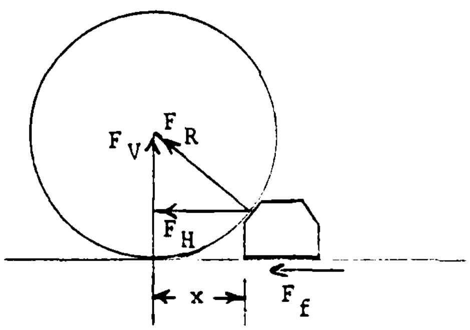

CHOCK RESTRAINT CAPABILITY FOR B-52H (TF33-P-3)
STANDARD 5" CHOCK
MAX GROUND WEIGHT (500,000) LBS
8 TIRES CHOCKED
4 TIRES CHOCKED
BASIC WEIGHT (183,350) LBS
GROSS WEIGHT (X 1000) LBS
140
180
220
260
300
340
380
420
460
500
NUMBER ENGINES AT 90% THRUST
8
7
6
5
4
3
2
NUMBER ENGINES AT MAX THRUST
8
7
6
5
4
3
2
1
CHOCK RESTRAINT FORCE (X 1000) LBS
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20

Figure 7

of thrust. This is a 30 percent increase in performance over the TF33-P-3 engine. Since the same aircraft structure and tires are being used on the KC-135R, the laboratory chock restraint data can be applied. By using the same average max chock restraint force and gross weight specified in Table 7, a plot similiar to figure 4 can be generated for the KC-135R, see figure 8.

y. Because of the increased thrust of the KC-135R engines, figure 8 shows that the standard 5 inch chock does not provide the margin of safety during engine runs as in the case of the -135A and -135E models. However, as long as 8 tires are chocked and there is at least 90,000 lbs of fuel on board, it would take four engines to roll over a standard chock during a brake failure. Figure 8 also shows that regardless of the aircraft gross weight, a four engine run can force the aircraft over the chocks if only 4 tires are chocked. Because of this fact, it became apparent that it would be worthwhile to see if the restraint capability of the current chock could be improved.

z. To improve the current chock, the force relationships between the chock and the tire must first be analyzed. Under perfect conditions, given a tire (no deflection) restrained by a block, the force relationship would be as that depicted in figure 9.



F_R = Chock Restraint Force
F_V = Vert Comp of FR
F_H = Horiz Comp of FR
F_f = Friction Force

Figure 9

The amount of friction force is a function of the coefficient of friction (μ) and the vertical load (N).

aa. To keep the chock from sliding, the horizontal force must be less than the friction force. Using $\mu = .38$ as the coefficient of friction for wood to pavement:

$$.38N > F_H$$

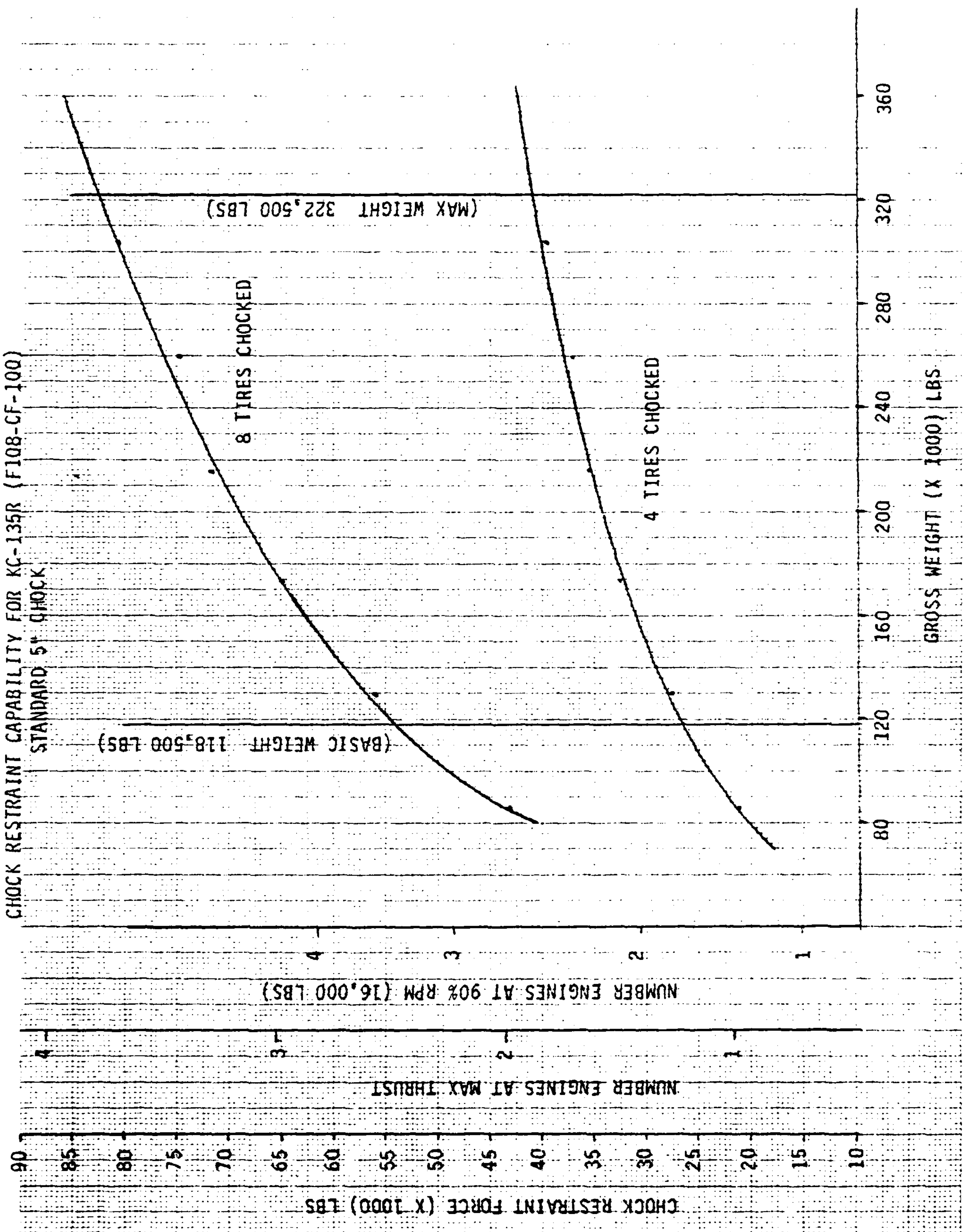
From figure 9, $F_H = F_R \sin \emptyset$
$F_V = F_R \cos \emptyset$

In this situation, the value of N is equal to F_V. Substituting F_V and F_H into the above formula:

$$.38 (F_R \cos \emptyset) > F_R \sin \emptyset$$

solving for $\emptyset$

$$\emptyset < \tan^{-1} .38$$



CHOCK RESTRAINT CAPABILITY FOR KC-135R (F108-CF-100)
STANDARD 5" CHOCK
8 TIRES CHOCKED
4 TIRES CHOCKED
(MAX WEIGHT 322,500 LBS)
(BASIC WEIGHT 118,500 LBS)
GROSS WEIGHT (X 1000) LBS
80 120 160 200 240 280 320 360
NUMBER ENGINES AT 90% RPM (16,000 LBS)
1 2 3 4
NUMBER ENGINES AT MAX THRUST
1 2 3 4
CHOCK RESTRAINT FORCE (X 1000) LBS
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

Figure 8

From this relationship, the angle Ø must be less than 20.8°. Using the maximum value of Ø, a maximum non-sliding chock height can be calculated. Using 24.5 inches as the -135 MLG tire radius, the maximum chock height is:

$$24.5\ [1 - \cos 20.8°] = 1.6 \text{ inches}$$

bb. Years of experience and the previous test data confirm that the currently used 5 inch chock is a non-slipping chock. Therefore, a 1.6 inch chock is unrealistic. In reality, if tire deflection is taken into account, the maximum chock height can be significantly increased.

cc. From the test data on a -135 tire, we know that the tire will deflect under minimum load; reducing the distance X (figure 9) by 8 to 11 inches. This tire deflection changes the max angle Ø from 42.97° to 53.5°.

$$\sin^{-1} \frac{24.5 \sin 20.8° + 8}{24.5} = 42.97°$$

$$\sin^{-1} \frac{24.5 \sin 20.8 + 11}{24.5} = 53.5°$$

These angles equate to chock heights of 6.55 and 9.93 inches. Note: these values will go down if the coefficient of friction goes down.

dd. Taking into account worst case situations and the tire compression against the support surface, a possible improvement to the current chock is to increase its height by 1.5 inches. Using a chock height of 6.5 inches, another laboratory test was conducted at WPAFB. Attachment 8 tabulates the -135 tire restraint test results using a 6.5 inch chock.

ee. Using the tabulated test results in attachment 8, the average maximum chock restraint force versus aircraft gross weight can be calculated for the four and eight chocked tire configurations. Using 24% MAC as the aircraft's center of gravity, Table 9 represents a tabulated comparisons of the above configurations.

Gross Weight	AVG MAX CHOCK RESTRAINT FORCE (FR)	
(lbs) Table 3	4 Chocked Tires	8 Chocked Tires
86,768	24600	49200
130,152	33360	66720
173,536	38480	76960
216,920	42160	84320
260,304	45040	90080
303,688	45680	91360

Table 9

-135 Gross Weight v.s. ANG MAX 6.5" Chock Restraint Force

Using Table 9, the valves can be plotted and again compared with the performance of the KC-135R engines, see figure 9. By using the 6.5 inch chock and a 120,000 lb fuel load, figure 10 shows that a KC-135R can be restrained with four engines running and no brakes.

ff. Figure 10 also shows a comparison between the 6.5 inch chock and 5 inch chock restraint capability under the 8 chocked tire configuration. By adding 1.5 inches to the height of the 5 inch chock, a 17 percent increase in capability is realized. This increased capability significantly improves the holding power and safety factor during engine run operations. Because of the improved performance of the 6.5 inch chock with the -135 aircraft, a performance analysis of its use with the B-52 was performed.

gg. The performance analysis of the 6.5 inch chock with the B-52 tire was done in the same manner as before. The test data was gathered at WPAFB laboratories, the restraint forces were tabulated (attachment 9), the four and eight chock restraint forces were tabulated (Table 10), and the results plotted (see figure 11).

Gross Wt (lbs)	AVG MAX CHOCK RESTRAINT FORCE (FR)	
(Table 8)	4 Chocked Tires	8 Chocked Tires
96,364	45400	90800
218,182	61317	122536
290,909	72532	145064
363,636	82400	164800
436,364	88668	177336
509,091	90800	181600

Table 10
B-52 Gross Weight v.s. Avg Max 6.5" Chock Restraint Force

hh. In the case of the B-52, the 6.5 inch chock provides 16 percent increase in capability over the 5 inch chock, see figure 11. The increased capability will prevent the B-52G aircraft from rolling over the chocks when all eight tires are chocked, no brakes, and all eight engines running at full thrust. In the case of the B-52H, under the same conditions, a fuel load of 80,000 lbs will prevent the aircraft from rolling over the chocks. With a 5 inch chock, a 180,000 lb fuel load is required to prevent the aircraft from rolling over the chocks. Therefore, a significant safety margin benefit can be realized by using the 6.5 inch chock with the B-52s.

ii. Under certain conditions, the aircraft can still roll over either the 5 inch or 6.5 inch chock. If this happens, the aircraft landing gear could possibly be damaged. According to Boeing Co., the B-52 and KC-135 are designed to go over a 4 inch bump without sustaining any damage.

kk. The design criteria for an engine run chock would have to take into account its operational useage. The chock should be mobile, safe-to-use, adequately restrain the aircraft, and not be a hazard to personnel or the aircraft. An experimental engine run chock was designed and tested at WPAFB. The chock was constructed of laminated oak with a 1/8 inch steel plate at each end. Three bolts were used to tie the laminated layers together and prevent separation under high loads, see attachment 10. This chock was tested using both the B-52 and -135 tire. Tire loading was the

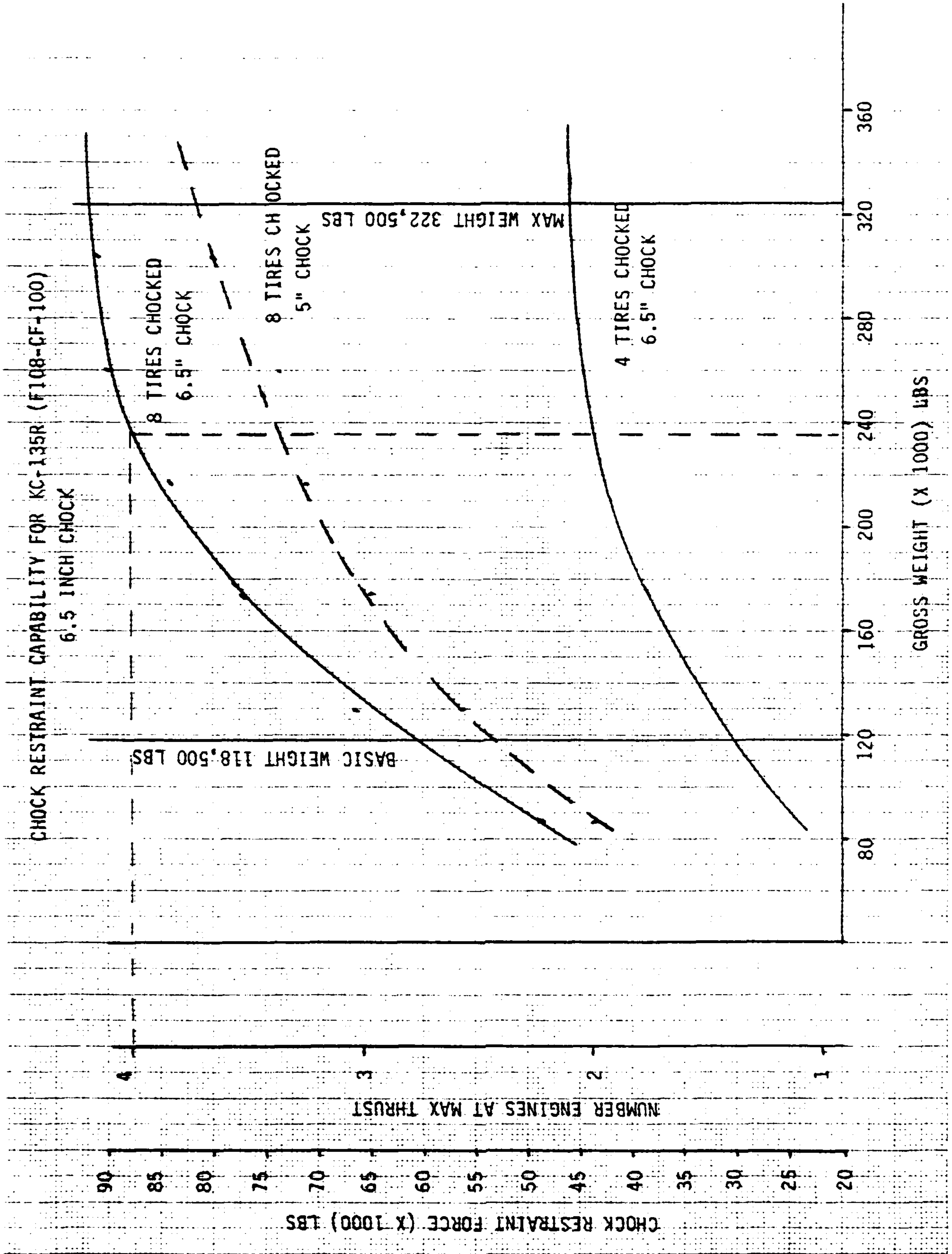

CHOCK RESTRAINT CAPABILITY FOR KC-135R (F108-CF-100)
6.5 INCH CHOCK
8 TIRES CHOCKED
6.5" CHOCK
8 TIRES CHOCKED
5" CHOCK
4 TIRES CHOCKED
6.5" CHOCK
MAX WEIGHT 322,500 LBS
BASIC WEIGHT 118,500 LBS
80 120 160 200 240 280 320 360
GROSS WEIGHT (X 1000) LBS
1 2 3 4
NUMBER ENGINES AT MAX THRUST
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
CHOCK RESTRAINT FORCE (X 1000) LBS

Figure 10

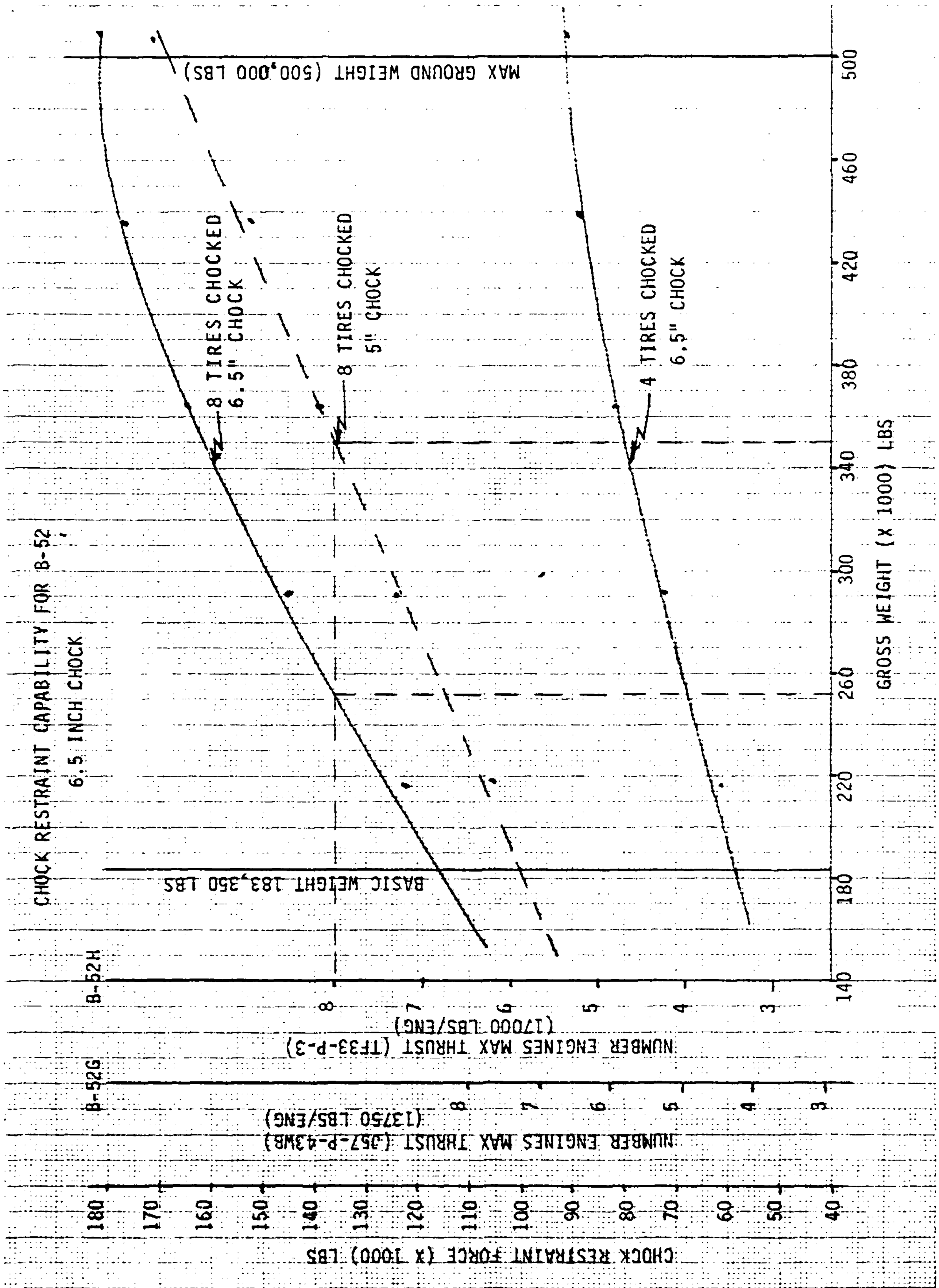

CHOCK RESTRAINT CAPABILITY FOR B-52
6.5 INCH CHOCK
MAX GROUND WEIGHT (500,000 LBS)
8 TIRES CHOCKED
6.5" CHOCK
8 TIRES CHOCKED
5" CHOCK
4 TIRES CHOCKED
6.5" CHOCK
BASIC WEIGHT 183,350 LBS
GROSS WEIGHT (X 1000) LBS
140
180
220
260
300
340
380
420
460
500
B-52H
NUMBER ENGINES MAX THRUST (TF33-P-3)
(17000 LBS/ENG)
8
7
6
5
4
3
B-52G
NUMBER ENGINES MAX THRUST (J57-P-43WB)
(13750 LBS/ENG)
8
7
6
5
4
3
CHOCK RESTRAINT FORCE (X 1000) LBS
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40

Figure 11

same as those used for the 5 inch and 6.5 inch chock test, see attachments 11 and 12 for the tabulated results. Tables 11 and 12 converts the tabulated results to aircraft gross weight and chocked tire configuration.

Gross Wt (lbs) Table 3	AVG MAX CHOCK RESTRAINT FORCE (FR) 4 Chocked Tires	8 Chocked Tires
86,768	15,680	31,360
130,152	26,080	52,160
173,536	36,480	72,960
216,920	47,440	94,880
260,304	58,320	116,640
303,688	67,680	135,360

Table 11
-135 Gross Wt v.s. AVG MAX Eng. Run Chock Restraint Force

Gross Wt (lbs) (Table 4)	AVG MAX CHOCK RESTRAINT FORCE (FR) 4 Chocked Tires	8 Chocked Tires
96,364	42,332	84,664
218,182	64,932	129,864
290,909	87,468	174,936
363,636	110,468	220,936
436,364	130,200	260,400
509,091	147,668	295,336

Table 12
B-52 Gross Wt v.s. AVG MAX Eng. Run Chock Restraint Force

Figures 12 and 13 compare the chock performance of the 5 inch, 6.5 inch, and engine run chocks for the KC-135 and B-52 aircraft, respectively.

kk. For the KC-135 aircraft, the engine run chock doesn't surpass the effectiveness of the current 5 inch chock until the gross weight exceeds 146,000 lbs. At lower aircraft weights, the engine run chock has a tendency to slide. Under lower coefficint of friction situations, i.e. icy or wet conditions, higher aircraft gross weights would be required to achieve the same effectiveness. As the aircraft weight increases, the effectiveness of the engine run chock increases significantly. At maximum thrust with four KC-135R engines, the aircraft gross weight minimum can be reduced by 48,000 lbs over the 6.5 inch chock. The current 5 inch chock is ineffective at this thrust setting.

ll. For the B-52, the engine run chock is equivalent to the 6.5 inch chock performance for light weight operations. However, the engine run chock quickly exceeds the restraint capability of the 6.5 inch and 5 inch chock and the max thrust capability of all eight TF-33 engines. The engine run chock can reduce the minimum aircraft gross weight by 24,000 lbs over the 6.5 inch chock and 110,000 lbs over the 5 inch chock.

mm. The engine run chock that was tested could cause some operational problems. Altough not hard to manufacture, the weight of each chock exceeded 400 lbs. This weight could cause problems in moving, handling, and positioning the chocks. If the chocks aren't positioned next to the tire, a spacing of over 6 inches could allow the tire to run up the chock and be kicked out with considerable force. Unless the engine run chocks are secured to the support surface, its additional restraint capability over the 6.5 inch chock is not worth the associated manufacturing cost and use problems. Under other conditions, versions of this chock could be more functional, but tests should be run to ensure safety.

nn. The purpose of this project was to determine the capability of the current 5 inch chock and develop a chock with more capability for engine run operations. By knowing what the current capability is, safe operating procedures can be developed. It was verified that the current procedures (attachment 2) are safe if they aren't violated. Another result was that the capability of the current chock can be significantly improved by adding 1.5 inches to its height. This 6.5 inch does not pose any additional handling or operating procedures over the current 5 inch chock. In addition, if the aircraft should roll over the 6.5 inch chock, because of tire deflection, the vertical movement of the strut would be less than 4 inches. The 4 inch vertical strut movement is the recommended safe limit. Finally, this report also shows that very little utility is gained by going to a larger engine run chock, but numerous handling problems would result.

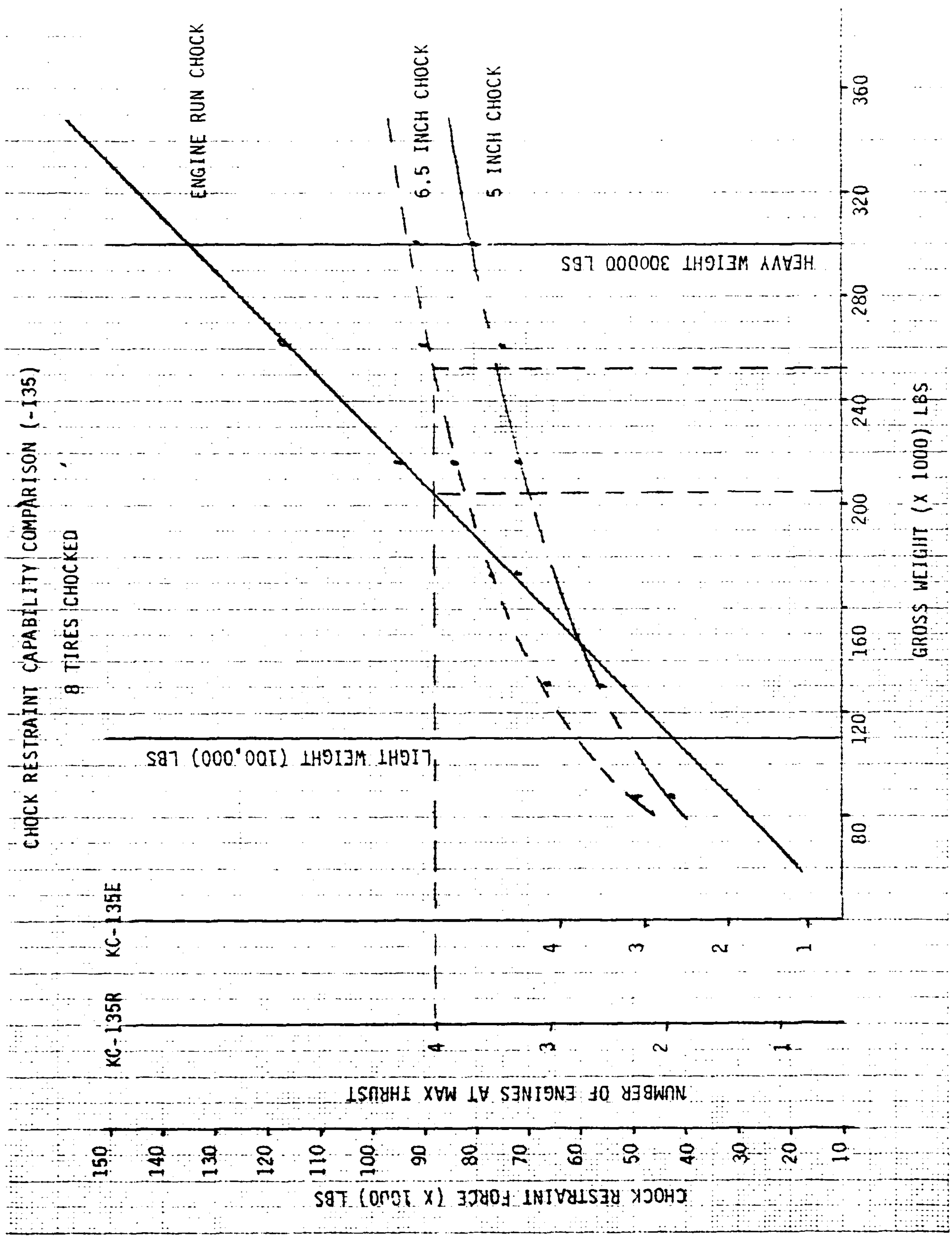
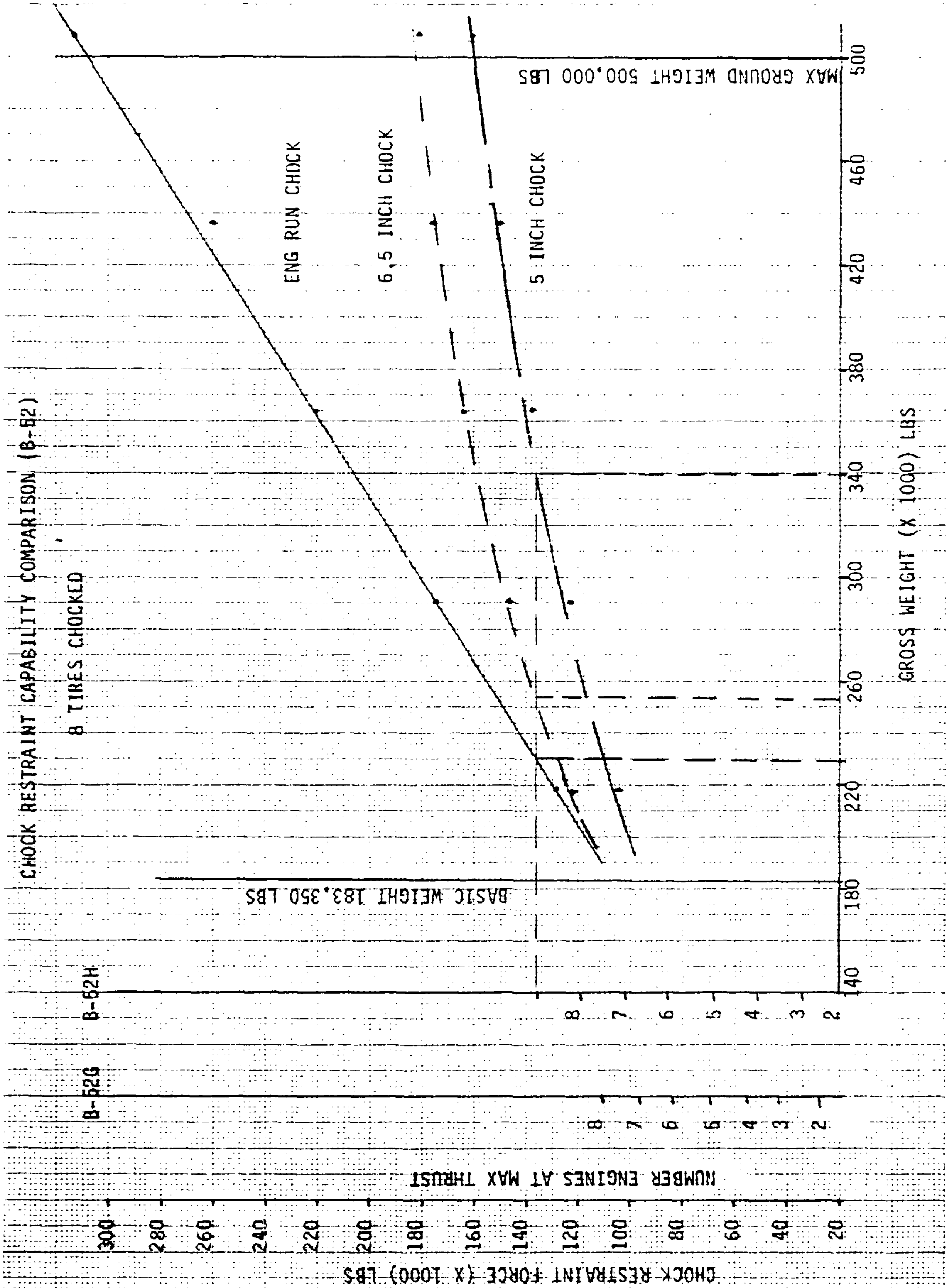

CHOCK RESTRAINT CAPABILITY COMPARISON (-135)
8 TIRES CHOCKED
ENGINE RUN CHOCK
6.5 INCH CHOCK
5 INCH CHOCK
HEAVY WEIGHT 300000 LBS
LIGHT WEIGHT (100,000) LBS
GROSS WEIGHT (X 1000) LBS
80
120
160
200
240
280
320
360
KC-135E
KC-135R
NUMBER OF ENGINES AT MAX THRUST
1
2
3
4
CHOCK RESTRAINT FORCE (X 1000) LBS
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

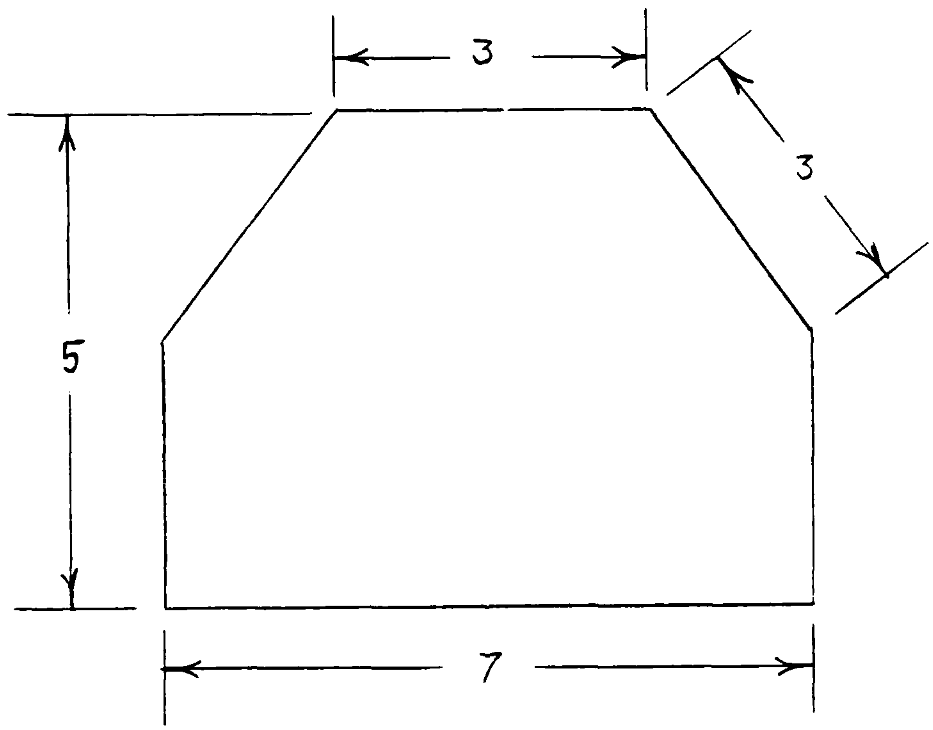
Figure 12



CHOCK RESTRAINT CAPABILITY COMPARISON (B-52)
8 TIRES CHOCKED
ENG RUN CHOCK
6.5 INCH CHOCK
5 INCH CHOCK
MAX GROUND WEIGHT 500,000 LBS
BASIC WEIGHT 183,350 LBS
GROSS WEIGHT (X 1000) LBS
140 180 220 260 300 340 380 420 460 500
B-52H
8 7 6 5 4 3 2
B-52G
8 7 6 5 4 3 2
NUMBER ENGINES AT MAX THRUST
300 280 260 240 220 200 180 160 140 120 100 80 60 40 20
CHOCK RESTRAINT FORCE (X 1000) LBS

Figure 13

STANDARD 5 Inch CHOCK



MATERIAL: WOOD

DEPARTMENT OF THE AIR FORCE
Headquarters Strategic Air Command
Offutt Air Force Base NE 68113

SAC SUPPLEMENT 1
AFR 60-11
10 September 1982

Flying

AIRCRAFT OPERATION AND MOVEMENT ON THE GROUND OR WATER

AFR 60-11, 21 June 1976, is supplemented as follows:

4.1. GENERAL:

a. Maintenance personnel occupying cockpit positions during ground engine runs will be qualified and certified engine run operators except as stated herein for training.

b. FB-111, KC-10, E-4, SR-71, U-2, TR-1, T-38 and T-39 aircraft, all engine runs will be accomplished by at least a seven level (primary AFSC) technician who is a qualified and certified engine run operator. All engine runs must be accomplished IAW applicable technical order.

c. All technical data procedures such as tie down requirements, opposite wing thrust for stability, single engine runs when possible, use of run fences, etc., must be strictly followed/enforced.

d. All B-52 and -135 aircraft will use six chocks during all maintenance engine runs. One chock in front of each main landing gear set of tires and one chock behind each rear main landing gear (aft set of tires). Ensure chocks are tight against tires for engine runs. All other aircraft will, as a minimum, have all main gears chocked front and aft with more restrictive technical orders/special instructions adhered to.

e. Prior to any maintenance engine run, the run supervisor will brief the OMS/flightline supervisor on all provisions of the run (i.e., which engines, what for, fuel on-board, chock placement, assigned duties of run crew, etc.).

4.2. B52 ENGINE OPERATIONS:

a. Two five level (control AFSC) technicians may run up to two engines at dry MRT in addition to engines 4 and 5 at idle for brake pressure on G and H aircraft.

b. Two five level (control AFSC) technicians may run up to two engines at dry MRT on B-52D aircraft.

c. All other engine runs will be accomplished by at least a seven level (primary AFSC) technician with a five level (control AFSC) technician occupying the second seat. The only exception is for training.

d. All water runs require a seven level (primary AFSC) technician with exception herein for training.

e. No more than four engines will be advanced above idle RPM at any one time.

f. When accomplishing training for engine operation, the following applies.

(1) A seven level technician will occupy either the pilot or copilot seat when providing training.

(2) No less than a five level (primary AFSC) will occupy one seat, with a seven level (primary AFSC) providing training on those operations which do not exceed the limitations given for two five level (control AFSC) technicians. Exception: one engine may be operated in water for training purpose only.

(3) All other runs by a seven level (primary AFSC) will be assisted by a five level (control AFSC) in the second seat.

g. B-52 aircraft must have the minimum fuel loads as specified below for engine operation:

(1) D and G models - 100,000 pounds.

(2) H models - 120,000 pounds.

4.3. -135 ENGINE OPERATIONS:

a. Operation of J57 engines:

(1) Two five level (control AFSC) technicians may run up to two engines at dry MRT.

(2) A seven level (primary AFSC) with a minimum of a five level (control AFSC) assisting may run up to four engines dry or no more than two engines wet.

(3) On those limited occasions where a four engine wet run is required, a qualified pilot team must run engines.

b. Operation of TF33 engines.

Supersedes AFR 60-11/SAC Sup 1, 4 September 1980.
No. of Printed Pages: 5
OPR: DOTU (Maj Byars)
Approved by: Col J. R. Mourning
Editor: M. Kadar
Distribution: F

(1) Two five level (control AFSC) technicians may run one engine to MRT with one additional engine providing symmetrical thrust not to exceed 90 percent.

(2) A seven level (primary AFSC) with assisting five level (control AFSC) may run up to four engines with two at MRT and the other two at no more than idle RPM. Three engines may be run at no more than 90 percent RPM.

c. All -135 aircraft will have symmetrical thrust when an outboard engine is run above 90 percent RPM.

d. When accomplishing training on engine operation, the following applies.

(1) A seven level technician will occupy either the pilot or copilot seat when providing training.

(2) No less than a five level (primary AFSC) will occupy the seat with a seven level (primary AFSC) providing training on those operations which do not exceed the limitations given for two five level (control AFSC) technicians.

(3) All other runs by a seven level (primary AFSC) will be assisted by a five level (control AFSC) in the second seat.

e. -135 aircraft must have the minimum fuel loads as specified below for engine operation:

(1) J57 - 2 engine run dry - 60,000.

J57 - more than 2 engines - any engine wet - 90,000.

(2) TF33 - 2 engine run - 200,000 aircraft minimum gross weight.

TF33 - more than 2 engines - 220,000 aircraft minimum gross weight.

The unit DCM will publish a maintenance operating instruction establishing minimum fuel loads for all TF-33 equipped -135 aircraft to ensure minimum gross weight criteria is met.

7a. Mechanics are not authorized to taxi B-52, E-4, EC-RC/KC-135, FB-111, KC-10, SR-71, TR-1, and U-2 aircraft with the following exception: The two 43191 personnel assigned to the CINCSAC Command Crew will be authorized to taxi C/KC-135 aircraft when movement of the aircraft is essential to support CINCSAC launch requirements and rated crew personnel are not available. Qualification and certification will be accomplished IAW paragraph 3 of the basic manual.

7d(1)(c)(Added). FB-111 aircraft may be taxied out of alert shelters as follows:

[1] Upon execution of the Emergency War Plan.

[2] During practice alerts.

[3] During initial alert response indoctrination training.

Prior to any aircraft taxi movement, safety measures will include a centerline painted in all shelters and a crew chief stationed on the inside turning corner of the shelter. (Note: Permission to use one crew chief vice two was granted to SAC by HQ USAF/XOODF, 181450Z Feb 77 message).

7e(Added). The pilot must ensure that their taxi speed is such that the ground marshallers are able to maintain their proper position. Taxi marshallers will use the SLOWDOWN/STOP signal if they cannot maintain their proper position.

10. Tow team supervisor will be included in this requirement.

10c. This qualification will be documented in the MMICS as follows:

(1) Towing team supervisor (type aircraft).

(2) Towing brake operator (type aircraft).

(3) Towing vehicle operator (type aircraft).

10d(Added). Personnel authorized to occupy the cockpit position of B-52, EC/KC/RC-135, E-4, SR-71, T-33, FB-111, KC-10, TR-1, and U-2 aircraft must be a five-level mechanic or above (or civilian equivalent assigned to transient maintenance) who is tow qualified as brake operator on aircraft to be towed.

10E Added

e. The towing supervisor (person with checklist) for routine towing operations involving B-52, C-135 series aircraft, SR-71, FB-111, E-4, KC-10, TR-1, and U-2 aircraft must be a five-level sergeant or above (civilian of comparable skill level in transient maintenance) who is tow qualified on aircraft to be moved. For all operations which involve the movement of SAC aircraft into or out of hangars, docks, alert shelters, etc., or into areas which are determined locally to be hazardous, a five-level SSgt or above will assume towing supervisor duty (person with checklist) for the movement of the aircraft. Towing to or away from the hangar/shelter or the hazardous area may be accomplished by a five-level sergeant tow supervisor.

NOTE: The number of five-level (Sgt) towing supervisors should be held to the absolute minimum necessary to ensure unit flexibility and safe flightline operations. DCMs must ensure the following minimum qualifications are met for five-level personnel approved as tow supervisors:

ENGINE OPERATIONS QUICK REFERENCE MATRIX

B-52 AIRCRAFT
D MODEL

PERSONNEL	2 ENG DRY MRT	MORE THAN 2 ENG	ANY ENG WET
Two - 5 Level (Control)	X		
One - 7 Level (Primary), One - 5 Level (Control)	X	X $$	X
FOR TRAINING ONLY			
One - 7 Level (Primary), One - 5 Level (Primary)	X		X $$$

$$ No more than 4 engines above idle at one time.

$$$ One engine may be operated in water for training.

G/H MODEL

PERSONNEL	2 ENG DRY MRT PLUS 4 and 5 ENGS FOR BRAKES	MORE THAN 2 ENG PLUS 4 & 5 ENGS FOR BRAKES	ANY ENG WET
Two - 5 Level (Control)	X		
One - 7 Level (Primary, One - 5 Level (Control)	X	X $$	X$
FOR TRAINING ONLY			
One - 7 Level (Primary), One - 5 Level (Primary)	X		X $$$

$ G Model

$$ No More than 4 engines above idle at one time.

$$$ One engine may be operated in water for training.

-135 AIRCRAFT
TF33 ENGINES

PERSONNEL	1-ENG MRT 1-BAL THRUST	4 ENGS 2-AT MRT 2-AT IDLE	3 ENGS NO MORE THAN 90 PERCENT RPM
Two - 5 Level (Control)	X $		
One - 7 Level (Primary, One - 5 Level (Control)	X $	X $$	X
FOR TRAINING ONLY One - 7 Level (Primary), One - 5 Level (Primary)	X $		

$ Must be opposite wing thrust for centerline balance.

$$ Engs at MRT must be on opposite wings.

-135 AIRCRAFT
J57 ENGINES

PERSONNEL	2 ENGS DRY MRT	4 ENGS 2 WET	ANY ENG WET	ALL ENGS WET
Two - 5 Level (Control)	X $			
One - 7 Level Primary, One - 5 Level (Control)	X $	X $$	X $	
FOR TRAINING ONLY One - 7 Level (Primary), One - 5 Level (Primary)	X $		X $$$	
Pilot Team				X

$ Must be opposite wing thrust for centerline balance.

$$ Engs at MRT or WET must be on opposite wings.

$$$ One engine may be operated in water for training.

HQ SAC/LGME TEST PLAN
NUMBER: P-425-T-1

AIRCRAFT ENGINEERING DIVISION (LGME)
Offutt Air Force Base Nebraska 68113

5 MAY 1982

CHOCKED TIRE ANALYSIS

Page

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Deputy Director of Aircraft Maintenan[illegible]
DCS/Logistics

Atch 3

1. **PURPOSE:** To determine the drag force/axial force, as a function of tire loading, necessary for a B-52 and a 135 tire to roll over a chock and to evaluate the tire deflection characteristics and vertical axial movement as the tire goes over the chock.

2. **AUTHORITY AND COORDINATION:** This test is a part of HQ SAC/LGME project P-425, Engine Run Chocks, which is being conducted under the provisions SACR 80-2. The project was approved on by HQ SAC/LGM.

3. **BACKGROUND:** During particular maintenance checks, there is a possibility that B-52 and 135 type aircraft can jump their chocks. Previous incidents of aircraft jumping their chocks have caused extensive damage to aircraft, therefore, an analysis is necessary to determine under what conditions an aircraft can jump its chocks. However, there is very little information/test data on B-52 and 135 tire charcteristics as the tire rolls over an obstacle. This information is necessary before acceptable accuracy can be determined for aircraft operating limitations and for design improvements on aircraft chocks.

4. **MODIFICATION:** No modifications to the B-52 and 135 tire or the standard 5" chock will be made. A larger chock will be fabricated to determine the effects of using a larger chock.

5. **TEST PROCEDURES:** The B-52 and 135 tires will be tested using specified loading, tire pressure, and chock size. Data will be collected relative to tire deflection and tire profile changes, drag force profile, and vertical strut movement as the tire rolls over the chock. All tests will be conducted on a smooth, dry surface and the tires will have no braking force applied. Observations will be noted as to whether the tire has a tendency to push the chock and whether or not the drag force profile changes if the chock is not in contact with the tire at the time of initial tire movement. Attachments 1 and 2 specify more detailed information on test specifications. Attachments 3 and 4 show the dimensions of the standard 5" chock and the proposed engine run chocks.

6. **ENVIRONMENTAL IMPACT:** There are no anticipated environmental impacts as a result of this test.

7. **TEST SCHEDULE AND DURATION:** Testing can begin as soon as test plan coordination and approval are accomplished, a firm cost estimate for the test is established, and the necessary funds are allocated and transferred. The duration of the test is expected to take two weeks.

8. **RESPONSIBILITIES:**

a. HQ SAC/LGME will:

(1) Coordinate all aspects of the test with the agencies involved.

(2) Provide a test plan to AFWAL/FIEMA

(3) Compile a final report when the test is completed.

b. AFWAL/FIEMA will:

(1) Provide a firm cost estimate to HQ SAC/LGME.

(2) Fabricate the proposed engine run chocks to specifications and ship to HQ SAC/LGME after the termination of the test.

(3) As a minimum, perform the test in accordance with attachments 1 and 2.

(4) Provide all test hardware, B-52 and 135 tires, and associated hardware necessary to perform the test.

(5) Collect, annotate, and forward all test results to HQ SAC/LGME.

(6) Provide 3/4" (max 20 minute) video tape(s) of those tests specified in attachments 1 and 2.

(7) Provide recommendations for improving the design of the chocks.

9. **POINTS OF CONTACT:**

a. HQ SAC/LGME	Capt Fuchser	294-3750
	Col Streett	294-4591
b. AFWAL/FIEMA	Mr. Skriblis	AV 785-2663

10. **IMPLEMENTING ACTIONS:**

a. HQ SAC/LGME will provide copies of the approved test plan to pertinent agencies.

b. Upon receipt of test plan, AFWAL/FIEMA will forward a cost estimate to HQ SAC/LGME.

c. HQ SAC will initiate a MIPR for funding and implementation of the test plan.

11. **REPORTING:** The final report on the tire analysis will be accomplished by HQ SAC/LGME.

DISTRIBUTION

5 - HQ SAC/LGME, Offutt AFB, NE 68113
3 - HQ SAC/LGMS/LGMM/LGMT, Offutt AFB, NE 68113
2 - AFWAL/FIEMA, Wright Patterson AFB, OH 45433

PROCEDURE

For each tire pressure, the tire will be tested using the tire loads specified. This procedure will be repeated for the standard 5" chock and the prototype chock. The chock will be in contact with the tire at the time of initial tire rotation.

In addition to the above tests, observations and data will be taken for the situation where the chock is 6 inches from the point of tire contact at time of initial tire rotation. This observation will be done using tire loads of 30,000 and 60,000 lbs at tire pressures of 260 and 300 psi. Specific note will be made of the drag profile and chock motion as the tire rolls over the chock. This data will be compared with that of the data where the tire is in contact with the chock at the time of initial rotation. If the data shows a significant change, the HQ SAC/LGME project officer will be contacted for guidance on pursuing any further testing in this area.

Documentation for this test will include still B&W photos of the test set up and tire profile as it rests on top of each chock. In addition, a video tape of the complete process of the tire rolling over the chock will be made using tire loads of 30,000 and 60,000 lbs at tire pressures of 260 and 300 psi.

Caution will be exercised at all times and provisions made so that if the tire kicks the chocks out from under the tire, personnel in the area will not be subjected to any danger.

APPENDIX 1

B-52 Tire Test Specifications

Input Data

Tire Loads: 20K, 30K, 40K, 50K, 60K and 70K lbs.

Tire Pressures: 240, 260, 280, 300, 320, 340 PSI.

Chock Size: Standard 5" chock, prototype chock.

Surface Condition: Smooth and dry.

Braking: 0 lbs.

Output Data

- Tire Deflection profile as the tire goes over the chock.
- Axial Drag Force profile as the tire goes over the chock.
- Vertical movement of the strut.
- Any unusual observations and/or visual tire damage will be noted.

Appendix II
135 Tire Test Specifications

Input Data

Tire Loads: 10K, 15K, 20K, 25K, 30K, and 35K lbs.

Tire Pressures: 120, 130, 140, 150, 160 psi.

Chock Size: Standard 5" chocks, prototype chock.

Surface Condition: Smooth and dry.

Braking: 0 lbs.

Output Data

- Tire deflection profile as the tire goes over the chock.
- Axial drag force profile as the tire goes over the chock.
- Vertical movement of the strut.
- Any unusual observations and/or visual tire damage will be noted.

Procedure

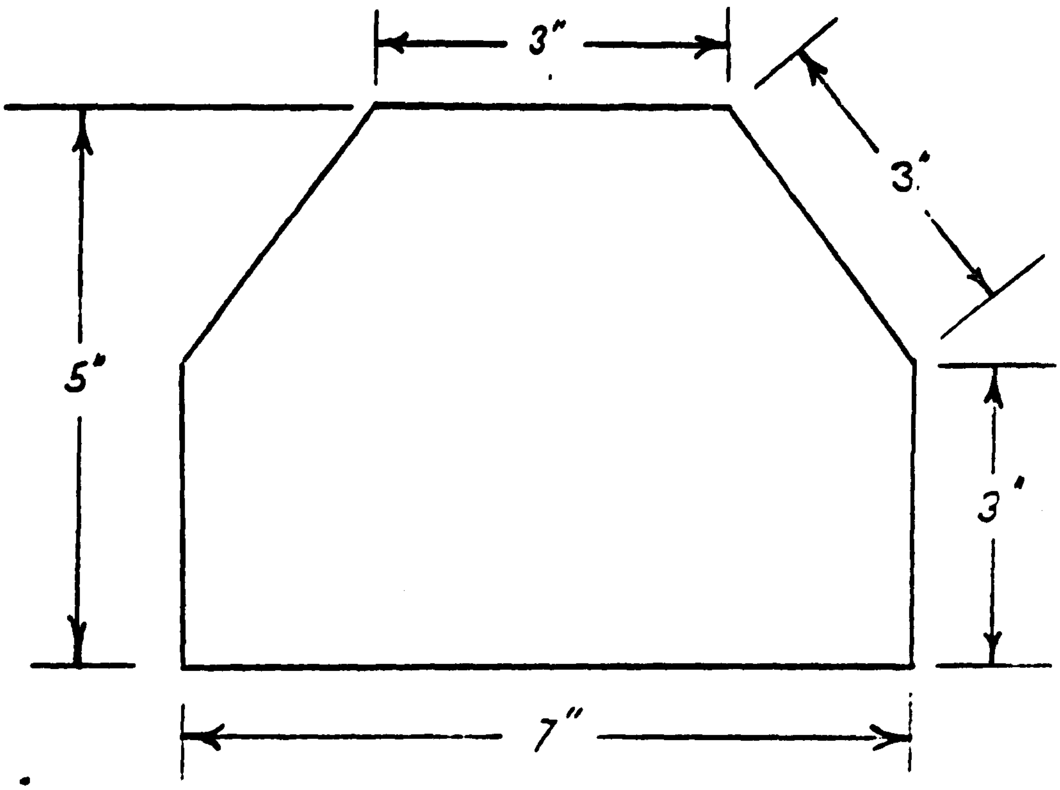
For each tire pressure, the tire will be tested using the tire loads specified. This procedure will be repeated for the standard 5" chock and the new prototype chock. The chock will be in contact with the tire at te time of initial tire rotation.

In addition to the above tests, observations and data will be taken for the situation where the chock is 6 inches from the point of contact at the time of initial tire rotation. This observation will be done using tire loads of 15,000 and 30,000 lbs at tire pressures of 130 and 150 psi. Secific note will be made of the drag profile and chock motion as the tire rolls over the chock. This data will be compared with that of the data where the tire is in contact with the chock at the time of initial tire rotation. If the data shows a significant change, the HQ SAC/LGME project officer will be contacted for guidance on pursuing any further testing in this area.

Documentation for this test will include still B&W photos of the test set up and the tire profile as it rests on top of each chock. In addition, a video tape of the complete process of the tire rolling over the chock will be made using tire loads of 15,000 and 30,000 lbs at tire pressures of 130 and 150 psi.

The same cautions apply in this test as in the B-52 tire test.

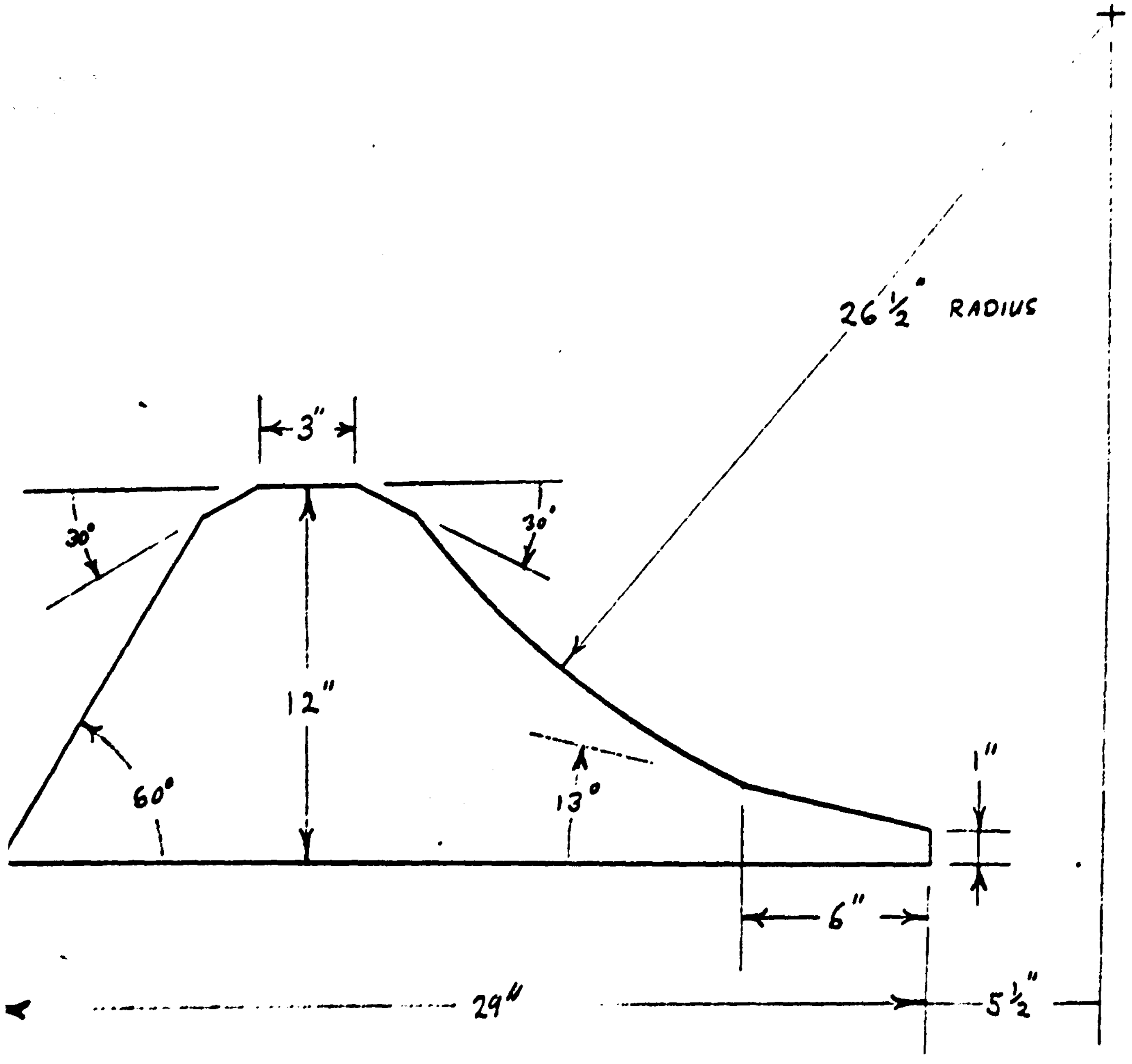
STANDARD 5" CHOCK



Scale: 1/2 inch equals 1 inch

Material: Wood

PROTOTYPE ENGINE-RUN CHOCK



Scale: 3/16 inch equals 1 inch

Material: Wood

Atch 3-4

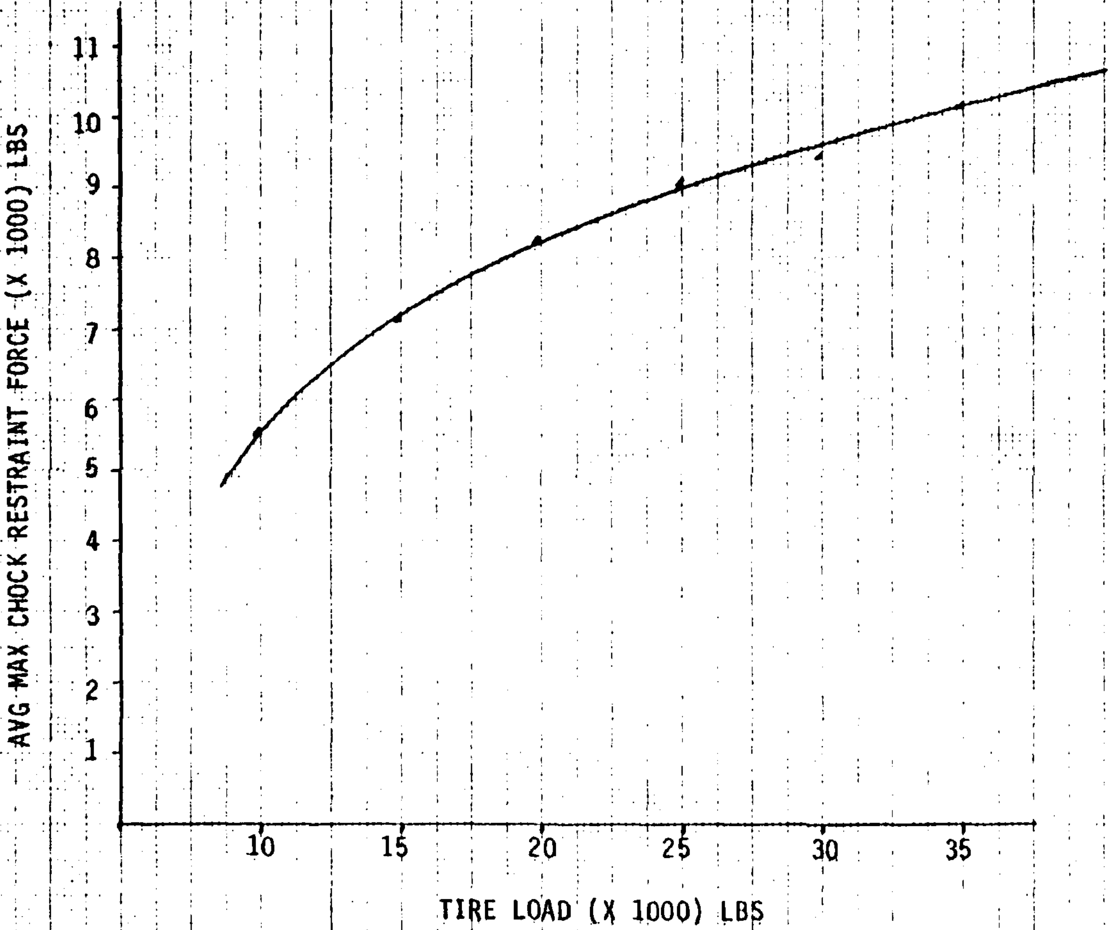
-135 Tire Restraint Test Results
Standard 5" Chock
Tire 49 x 17/26 PR

Tire Load (lbs)	Tire Pressure (PSI)	MAX Chock Restraint Force (lb_f)
10,000	120	5,000
15,000	120	6,400
20,000	120	7,500
25,000	120	8,000
30,000	120	8,800
35,000	120	10,400
10,000	130	5,400
15,000	130	6,900
20,000	130	7,900
25,000	130	8,700
30,000	130	9,300
35,000	130	9,400
10,000	140	5,500
15,000	140	7,100
20,000	140	8,200
25,000	140	9,000
30,000	140	9,300
35,000	140	9,800
10,000	150	5,700
15,000	150	7,400
20,000	150	8,500
25,000	150	9,400
30,000	150	9,500
35,000	150	10,200
10,000	160	5,700
15,000	160	7,600
20,000	160	8,800
25,000	160	9,800
30,000	160	9,900
35,000	160	10,600

Tire Load (lbs)	AVG Tire Pressure (PSI)	AVG MAX Chock Restraint Force (lb_f)
10,000	140	5,460
15,000	140	7,080
20,000	140	8,180
25,000	140	8,980
30,000	140	9,360
35,000	140	10,080

-135 CHOCK RESTRAINT TEST RESULTS

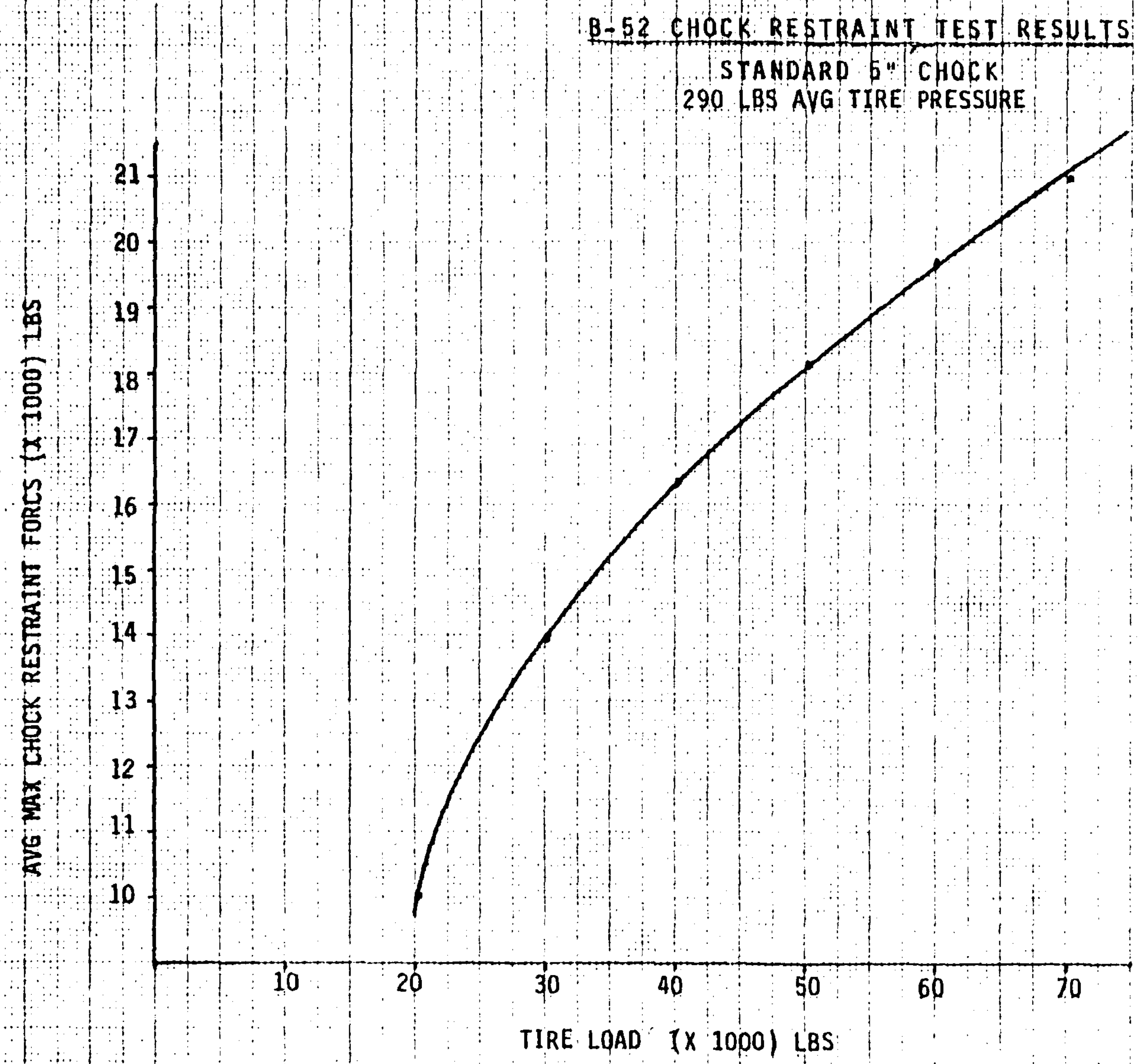
STANDARD 5" CHOCK
140 LBS AVG TIRE PRESSURE



B-52 Tire Restraint Test Results
Standard 5" Chock
Tire 56 x 16/38 PR

Tire Load (lbs)	Tire Pressure (PSI)	MAX Chock Restraint Force (lb_f)
20,000	240	10,200
30,000	240	13,600
40,000	240	15,500
50,000	240	17,000
60,000	240	18,400
70,000	240	19,500
20,000	260	10,600
30,000	260	13,400
40,000	260	15,600
50,000	260	17,300
60,000	260	18,900
70,000	260	19,700
20,000	280	10,600
30,000	280	13,800
40,000	280	16,400
50,000	280	18,000
60,000	280	19,800
70,000	280	21,200
20,000	300	11,000
30,000	300	14,000
40,000	300	16,300
50,000	300	18,200
60,000	300	19,700
70,000	300	21,100
20,000	320	11,000
30,000	320	14,300
40,000	320	17,000
50,000	320	19,200
60,000	320	20,400
70,000	320	22,000
20,000	340	11,400
30,000	340	14,600
40,000	340	17,400
50,000	340	19,200
60,000	340	21,200
70,000	340	22,500

Tire Load (lbs)	AVG Tire Pressure (PSI)	AVG MAX Chock Restraint Force (lb_f)
20,000	290	10,800
30,000	290	13,950
40,000	290	16,367
50,000	290	18,150
60,000	290	19,733
70,000	290	21,000

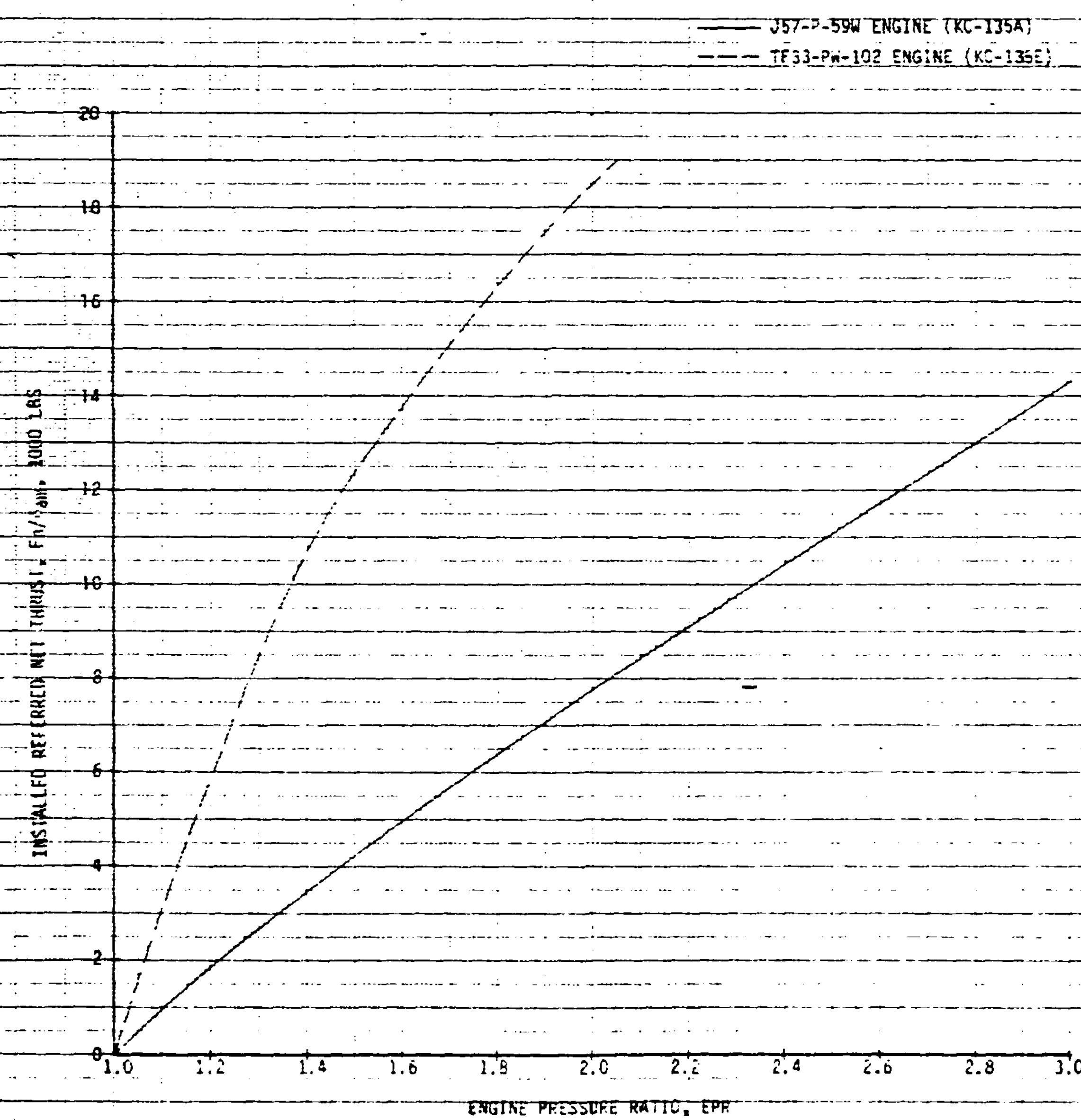


B-52 CHOCK RESTRAINT TEST RESULTS
STANDARD 5" CHOCK
290 LBS AVG TIRE PRESSURE
AVG MAX CHOCK RESTRAINT FORCS (X 1000) LBS
21
20
19
18
17
16
15
14
13
12
11
10
10
20
30
40
50
60
70
TIRE LOAD (X 1000) LBS

~~J57-P-59W AND TF33-PW-102 (TF33-P-5) ENGINES~~
INSTALLED THRUST PERFORMANCE FOR KC-135A AND KC-135E AIRPLANES
DURING STATIC, GROUND OPERATION

NOTES:

- INSTALLATION EFFECTS INCLUDE:
  - INLET LOSS
  - EXHAUST NOZZLE LOSS
  - ~~SCRUBBING LOSS (FOR TF33-PW-102 ONLY)~~
- NO BLEED OR POWER EXTRACTION

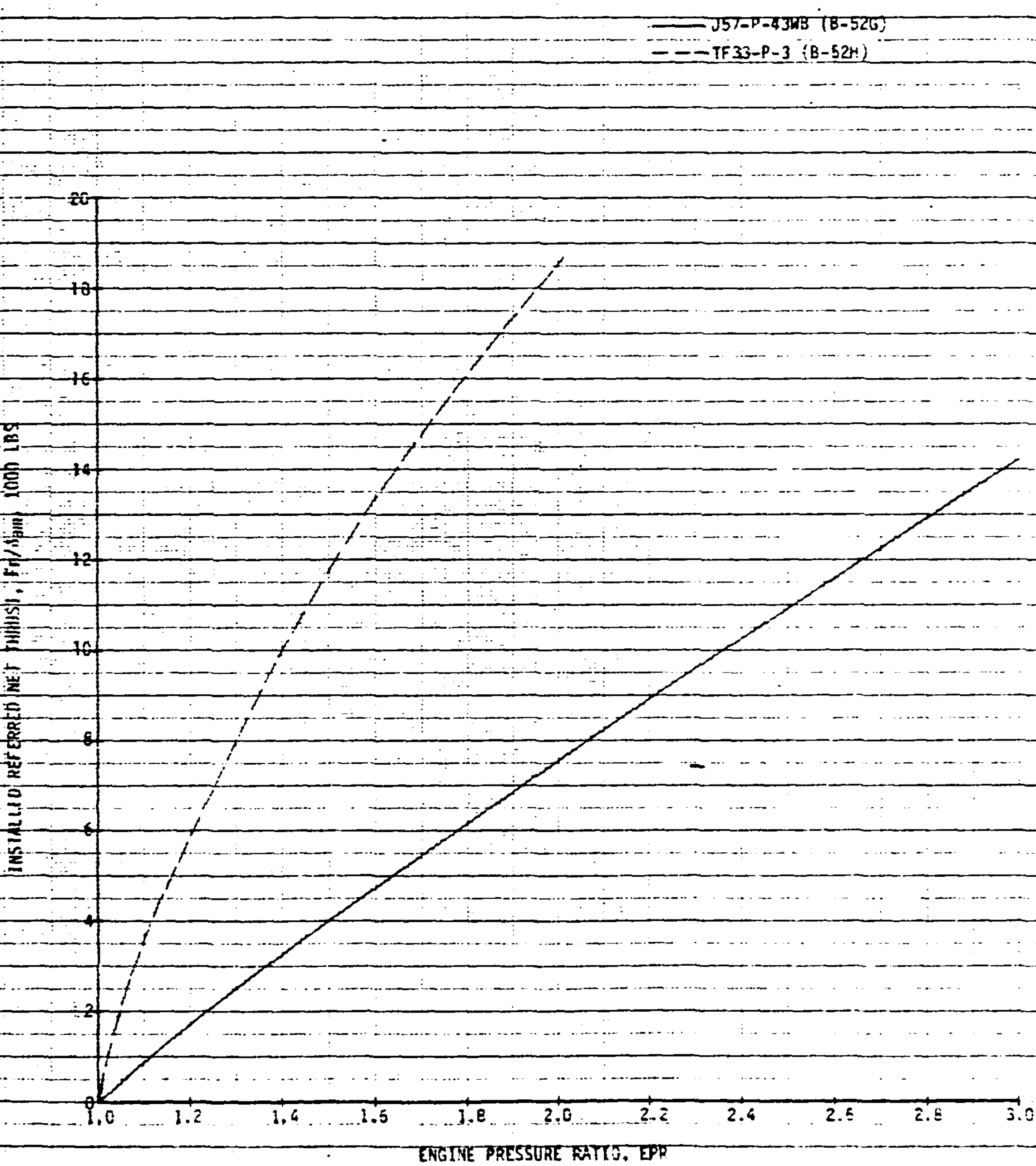


DC/EA 2/21/84

J57-P-43WB AND TF33-P-3 ENGINES
INSTALLED THRUST PERFORMANCE FOR B-52G AND H AIRPLANES
DURING STATIC, GROUND OPERATION

NOTES:

- INSTALLATION EFFECTS INCLUDE:
  - INLET LOSS
  - EXHAUST NOZZLE LOSS
  - SCRUBBING LOSS (TF33-P-3 ONLY)
- NO BLEED OR POWER EXTRACTION

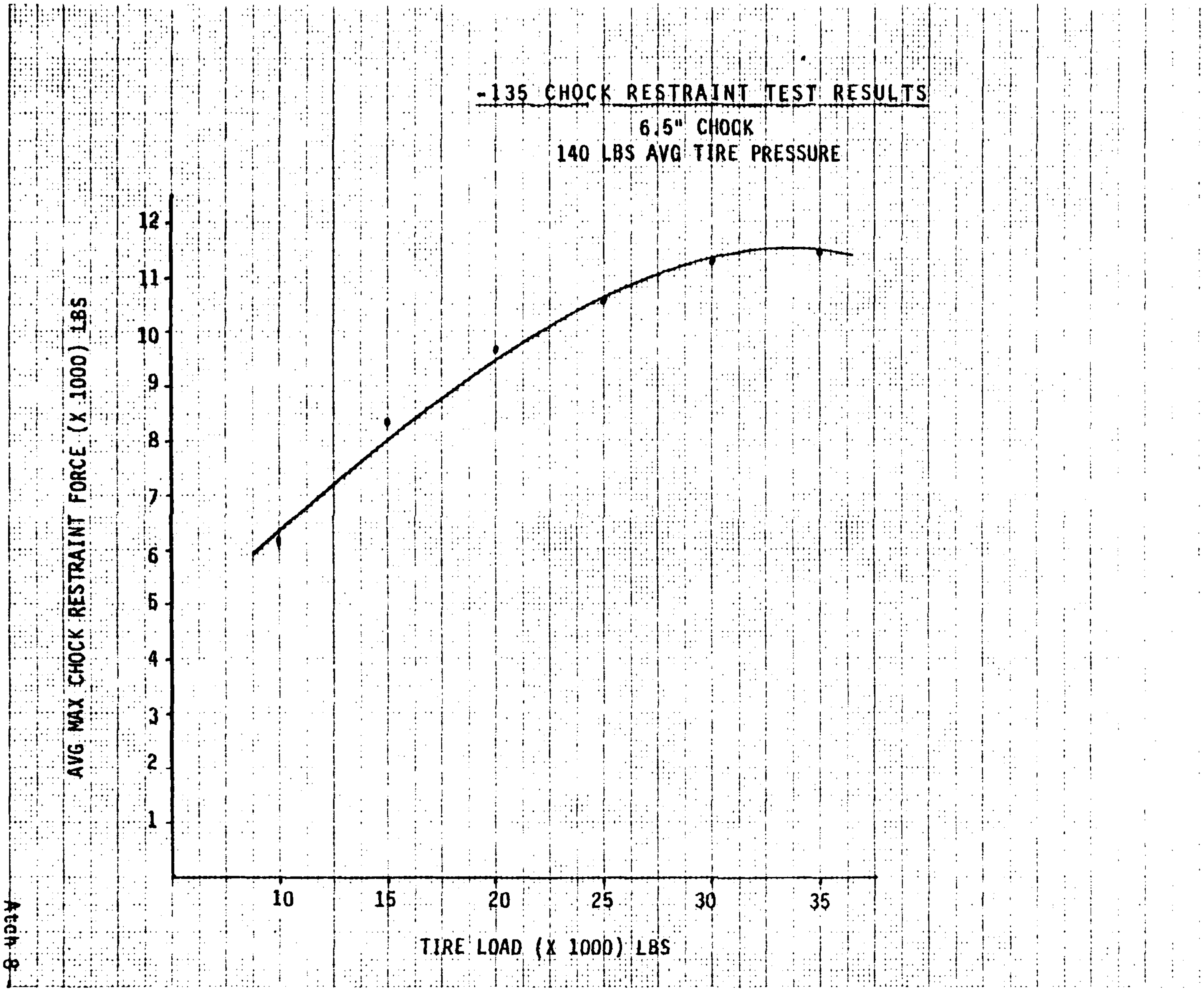


CT/E4 2/21/84

-135 Tire Restraint Test Results
6.5" Chock
Tire 49 x 17/26 PR

Tire Load (lbs)	Tire Pressure (PSI)	MAX Chock Restraint Force (lb_f)
10,000	120	6,300
15,000	120	7,600
20,000	120	8,800
25,000	120	9,200
30,000	120	10,500
35,000	120	11,400
10,000	130	6,000
15,000	130	8,300
20,000	130	9,000
25,000	130	10,300
30,000	130	11,000
35,000	130	12,000
10,000	140	Chock slides
15,000	140	8,500
20,000	140	9,500
25,000	140	10,200
30,000	140	11,000
35,000	140	12,000
10,000	150	Chock slides
15,000	150	8,700
20,000	150	11,400
25,000	150	11,800
30,000	150	11,800
35,000	150	11,400
10,000	160	Chock slides
15,000	160	8,600
20,000	160	10,400
25,000	160	11,200
30,000	160	12,000
35,000	160	10,300

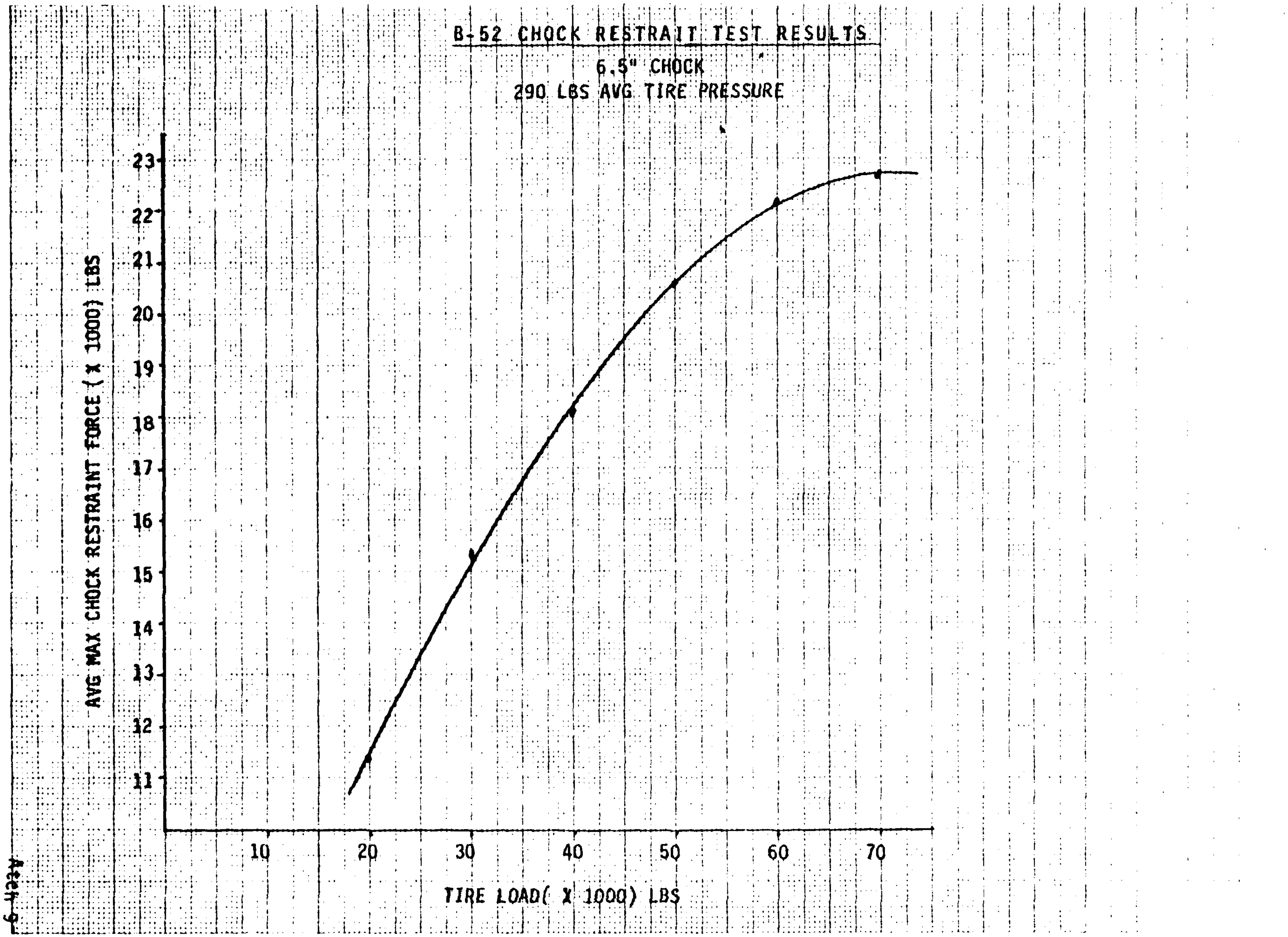
Tire Load (lbs)	AVG Tire Pressure (PSI)	AVG MAX Chock Restraint Force (lb_f)
10,000	140	6,150
15,000	140	8,340
20,000	140	9,620
25,000	140	10,540
30,000	140	11,260
35,000	140	11,420


-135 CHOCK RESTRAINT TEST RESULTS
6.5" CHOCK
140 LBS AVG TIRE PRESSURE
AVG MAX CHOCK RESTRAINT FORCE (X 1000) LBS
12
11
10
9
8
7
6
5
4
3
2
1
10
15
20
25
30
35
TIRE LOAD (X 1000) LBS

-B-52 Tire Restraint Test Results
6.5" Chock
Tire 56 x 16/30 PR

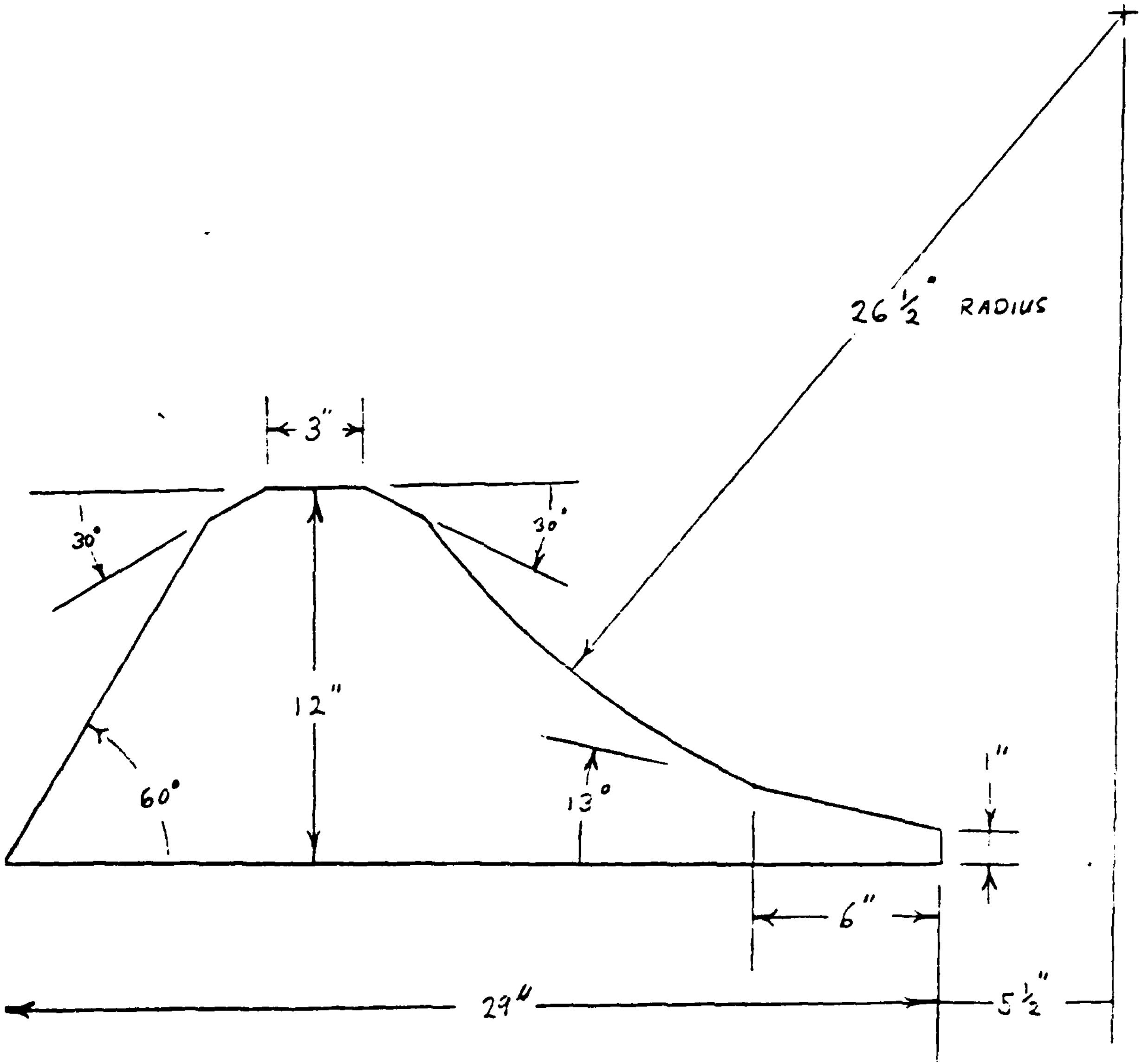
Tire Load (lbs)	Tire Pressure (PSI)	MAX Chock Restraint Force (lb_f)
20,000	240	11,500
30,000	240	15,100
40,000	240	17,400
50,000	240	19,400
60,000	240	21,000
70,000	240	21,200
20,000	260	10,000
30,000	260	15,000
40,000	260	17,000
50 000	260	20,400
60,000	260	21,600
70,000	260	22,600
20,000	280	11,600
30,000	280	15,400
40,000	280	18,400
50,000	280	20,800
60,000	280	22,200
70,000	280	23,000
20,000	300	11,600
30,000	300	14,800
40,000	300	18,400
50,000	300	21,000
60,000	300	22,200
70,000	300	23,000
20,000	320	11,600
30,000	320	15,800
40,000	320	18,600
50,000	320	20,600
60,000	320	22,400
70,000	320	23,400
20,000	340	11,800
30,000	340	15,800
40,000	340	19,000
50,000	340	21,400
60,000	340	23,600
70,000	340	23,000

Tire Load (lbs)	AVG Tire Pressure (PSI)	AVG MAX Chock Restraint Force (lb
20,000	290	11,350
30,000	290	15,317
40,000	290	18,133
50,000	290	20,600
60,000	290	22,167
70,000	290	22,700



B-52 CHOCK RESTRAIT TEST RESULTS
6.5" CHOCK
290 LBS AVG TIRE PRESSURE
AVG MAX CHOCK RESTRAINT FORCE (X 1000) LBS
23
22
21
20
19
18
17
16
15
14
13
12
11
10
20
30
40
50
60
70
TIRE LOAD(X 1000) LBS

PROTOTYPE ENGINE-RUN CHOCK



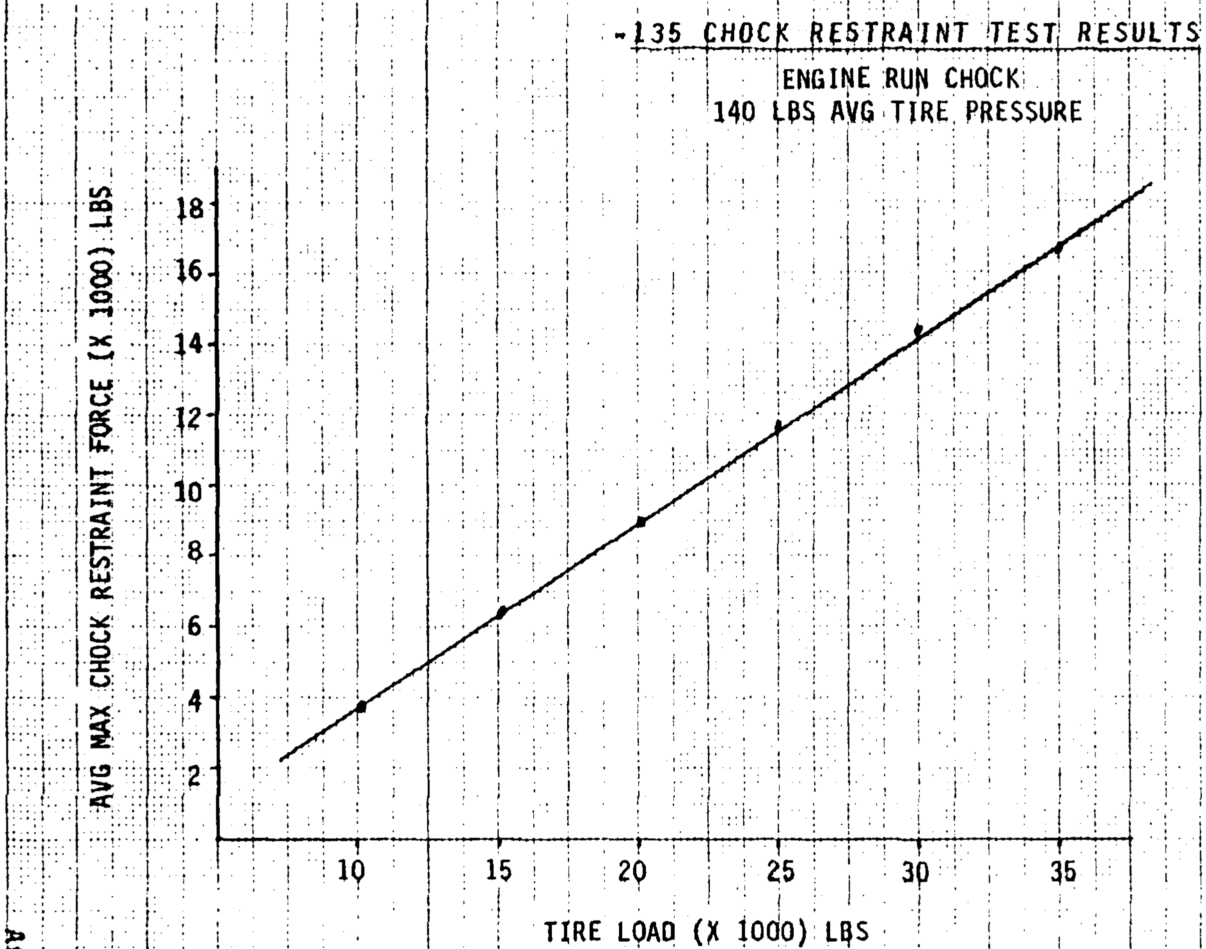
Scale: 3/16 inch equals 1 inch

Material: Wood

-135 Tire Restraint Test Results
Engine Run Chock
Tire 49 x 17/26 PR

Tire Load (lbs)	Tire Pressure (PSI)	MAX Chock Restraint Force (lb_f)
10,000	120	4,100
15,000	120	6,400
20,000	120	9,400
25,000	120	11,800
30,000	120	14,500
35,000	120	17,300
10,000	130	3,800
15,000	130	6,500
20,000	130	8,900
25,000	130	12,000
30,000	130	14,600
35,000	130	16,800
10,000	140	3,900
15,000	140	6,500
20,000	140	9,200
25,000	140	12,000
30,000	140	14,900
35,000	140	16,600
10,000	150	3,700
15,000	150	6,500
20,000	150	9,200
25,000	150	11,900
30,000	150	14,500
35,000	150	17,200
10,000	160	4,100
15,000	160	6,700
20,000	160	9,000
25,000	160	11,600
30,000	160	14,400
35,000	160	16,700

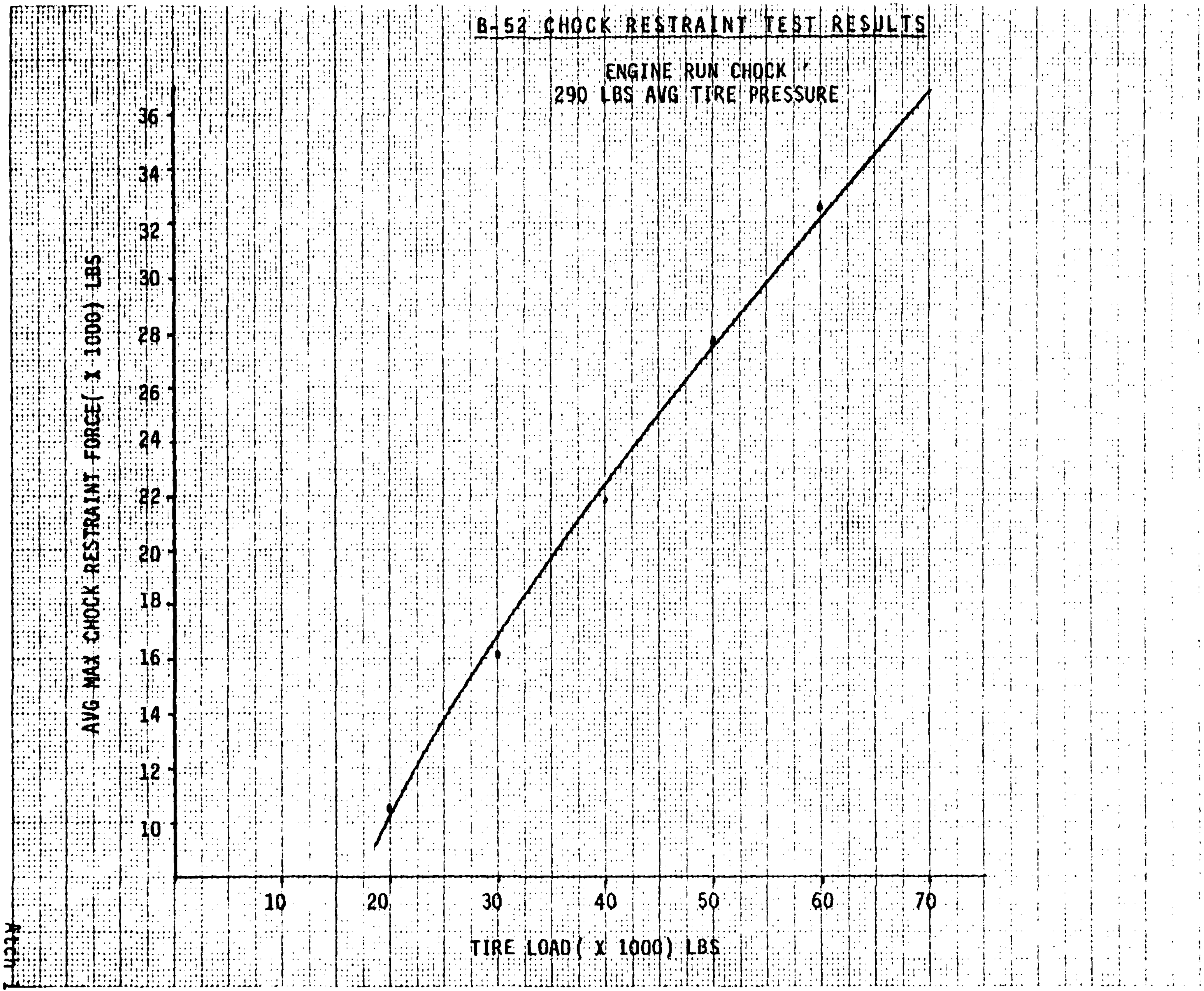
Tire Load (lbs)	AVG Tire Pressure (PSI)	AVG MAX Chock Restraint Force (lb_f)
10,000	140	3,920
15,000	140	6,520
20,000	140	9,120
25,000	140	11,860
30,000	140	14,580
35,000	140	16,920


-135 CHOCK RESTRAINT TEST RESULTS
ENGINE RUN CHOCK
140 LBS AVG TIRE PRESSURE
AVG MAX CHOCK RESTRAINT FORCE (X 1000) LBS
18
16
14
12
10
8
6
4
2
10
15
20
25
30
35
TIRE LOAD (X 1000) LBS

-B-52 Tire Restraint Test Results
Engine Run Chock
Tire 56 x 16/38 PR

Tire Load (lbs)	Tire Pressure (PSI)	MAX Chock Restraint Force (lb_f)
20,000	240	8,000
30,000	240	12,400
40,000	240	17,400
50,000	240	21,400
60,000	240	24,300
70,000	240	29,500
20,000	260	8,600
30,000	260	13,600
40,000	260	18,300
50,000	260	23,200
60,000	260	28,000
70,000	260	32,800
20,000	280	9,700
30,000	280	15,000
40,000	280	20,400
50,000	280	26,800
60,000	280	32,500
70,000	280	39,000
20,000	300	11,800
30,000	300	18,200
40,000	300	24,500
50,000	300	30,700
60,000	300	36,400
70,000	300	40,000
20,000	320	12,400
30,000	320	18,000
40,000	320	23,600
50,000	320	29,900
60,000	320	34,600
70,000	320	40,000
20,000	340	13,000
30,000	340	20,200
40,000	340	27,400
50,000	340	33,700
60,000	340	39 500
70,000	340	40,200

Tire Load (lbs)	AVG Tire Pressure (PSI)	AVG MAX Chock Restraint Force (lb
20,000	290	10,583
30,000	290	16,233
40,000	290	21,867
50,000	290	27,617
60,000	290	32,550
70,000	290	36,917


B-52 CHOCK RESTRAINT TEST RESULTS
ENGINE RUN CHOCK
290 LBS AVG TIRE PRESSURE
AVG MAX CHOCK RESTRAINT FORCE(X 1000) LBS
36
34
32
30
28
26
24
22
20
18
16
14
12
10
10
20
30
40
50
60
70
TIRE LOAD(X 1000) LBS

12 Attachments

1. Standard Chock Dimensions
2. SAC Sup 1, AFR 60-11
3. Test Plan P-425-T-1
4. KC-135 Tire Restraint Test Results (5 Inch Chocks)
5. B-52 Tire Restraint Test Results (5 Inch Chocks)
6. Engine Performance Curves KC-135A, and KC-135E
7. Engine Performance Curves B-52G and H
8. KC-135 Test Results (6.5 Inch Chocks)
9. B-52 Test Results (6.5 Inch Chocks)
10. Prototype Engine Run Chock Dimensions
11. KC-135 Test Results (Engine Run Chocks)
12. B-52 Test Results (Engine Run Chocks)

DISTRIBUTION

8 - HQ SAC/LGME/LGMSB/LGMST/LGMTT, Offutt AFB, NE 68113

2 - OC-ALC/MMPR/MMSRK, Tinker AFB, OK 73145

2 - NGB/LGM Pentagon, Room 2D369, Washington DC, 20310

1 - 171 ARW(ANG)/MAQ, Greater Pittsburgh Intl. Airport, PA 15108

1 - AFWAL/FIEMA, Wright Patterson AFB, OH 45433

1 - 171 ARW/MAQ, Greater Pittsburgh Intl. Airport, PA 15108